POWER

Vol. 46 NEW YORK, NOVEMBER 6, 1917 No. 19

While The City Sleeps

Drawn by H. G. Gibson, Washington, D. C.

Testing Chicago's New Centrifugal Pumps

Two 30,000,000-gal. steam-turbine, reduction-gear centrifugal pumps equipped throughout with hydraulic-driven auxiliaries. Operating against a head of 140 ft. and delivering water at the rate of 33.85 million gallons per 24 hours, a duty of 135,000,000 ft.-lb. per 1000 lb. of steam was developed.

SIXTY-EIGHTH Street Pumping Station, Chicago, has been undergoing a period of reconstruction. It contained a number of old horizontal compound pumping engines developing relatively low duties when compared to present-day standards and some water-tube boilers installed in 1906. The question of moving the station to a new location or erecting a new plant on the same site had been considered, but it was eventually decided to make use of the boilers as they stood for their full commercial life. Increasing demand for water and excessive repairs on the old pumping engines, however, demanded immediate attention. The first relief was the installation of two 20,000,000-gal. centrifugal pumping units that had been used temporarily at Lake View Station, these units replacing one of the old 12,000,000-gal. pumping engines. The next step was to replace two more of the old units of the size mentioned by the two 30,000,000-gal. centrifugal units under description. As the centrifugals had to fit the space occupied by the old pumps, they are of compact design, the arrangement being shown in the accompanying illustrations. A distinctive feature is the use of hydraulic-driven auxiliaries throughout.

The two units are duplicates, each being rated at 30,000,000 gal. per 24 hours against a head of 140 ft. and 36,000,000 gal. against a head of 130 ft. Each pump has its own suction well from which the water is drawn through a 16-in. twin strainer and then through a suction surface condenser before reaching the pumps. The condenser is of the Worthington water-works steam-tube type with hinged doors operating on rails after the city's design. Each condenser contains 1900 sq.ft. of cooling surface, the tubes being 1¼ in. diameter and 8 ft. long.

In leaving the pump the water passes through a venturi meter that is preceded in the discharge line by a straight pipe of suitable length to insure the proper operation of the meter. The downstream portion of the meter has a long-radius bend and leads directly to a large multiple-disk check valve beyond which is a hydraulically operated shutoff valve.

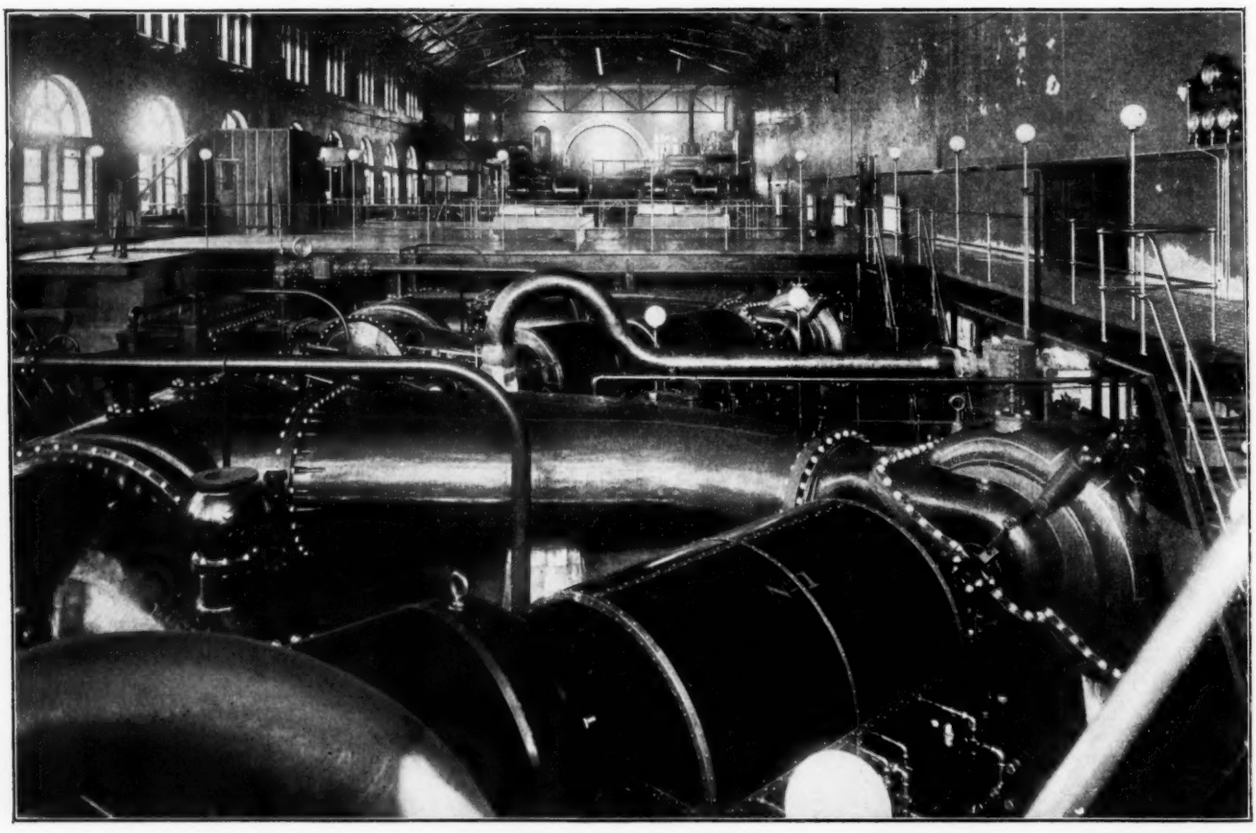


FIG. 1. THIRTY-MILLION-GALLON CENTRIFUGAL PUMPING UNITS

The pump proper is of the Worthington horizontal single-impeller double-suction type without diffusion blades and is driven through reduction gearing by a steam turbine. To insure rigidity of alignment, the pump, reduction gear and turbine are all mounted on a single sole plate. The turbine is a horizontal, condensing, multi-stage, nozzle-and-blade impulse machine,

with parallel steam flow. It is provided with an oil relay speed-control governor, a constant water-pressure governor, and also an emergency overspeed governor arranged to trip a steam-operated stop valve in the steam-supply pipe. Forced lubrication is provided for the main-turbine and reduction-gear bearings. The return oil is cooled by water-circulating pipes in an oil reservoir in the base of the turbine.

An outstanding feature of the installation is the use of hydraulically driven auxiliaries. There is a hydraulic vacuum pump using water taken from the main-pump discharge line for removing the noncondensable vapors from the top of the condenser. This is effected by hurling at high velocity jets of water approximately rectangular in cross-section from a revolving wheel. The water jets rush through the discharge cone and diffuser of the pump in the form of a helix, inclosing the vapors which enter around the rotary transforming wheel between the jets of water. A cross-section of this pump is shown in Fig. 3. As the discharge from the air pump is not contaminated with oil or other objectionable impurities, it is conducted back to the main suction well. An absolute pressure of less than 1 in. of mercury can be maintained by this pump. For starting up, provision is made to draw the water from the street side of the check valve. A vertical-shaft four-stage centrifugal pump drains the water from the condenser hotwell. It is set in a pit so that the suction is under head. The pump is driven by a Pelton vertical waterwheel receiving its pressure water from the discharge line of the main pump. As in the case of the vacuum pump, the spent water goes back to the main suction well. The condensate is discharged into a heater in the boiler room against a head of approximately 40 ft. Table I on the following page gives the principal dimensions, weight, speed and other data relating to the pumping units.

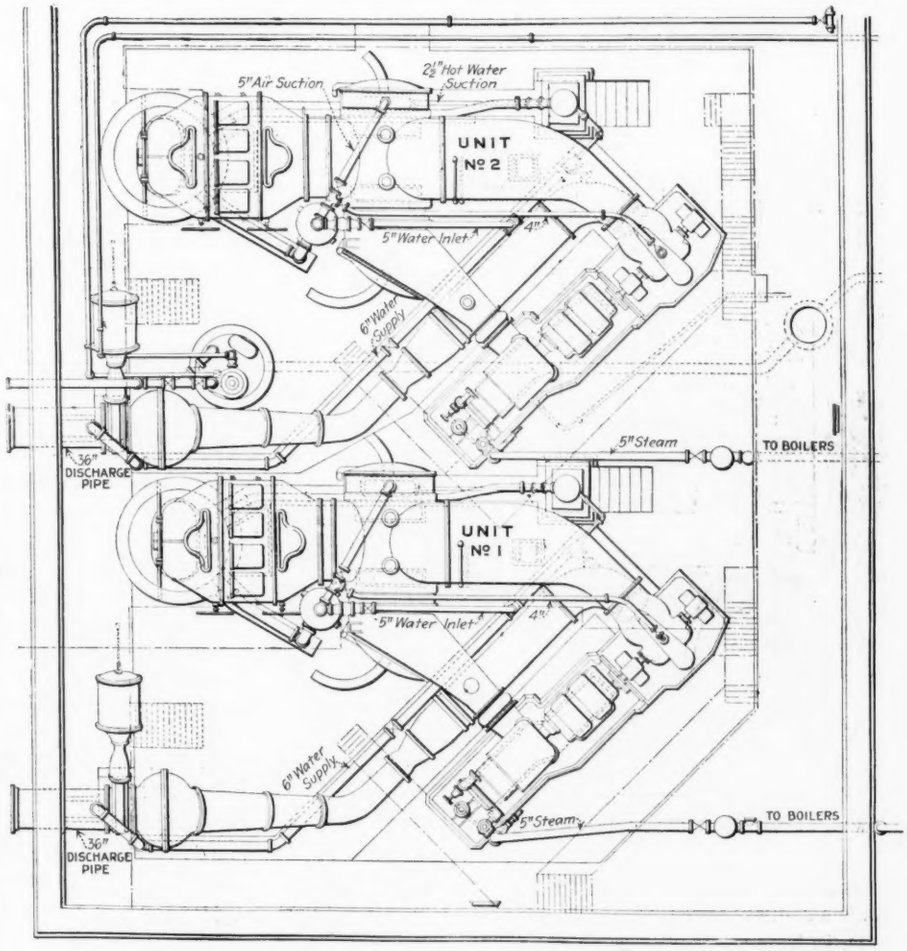


FIG. 2. GENERAL ARRANGEMENT OF THE TWO PUMPING UNITS

As the pumps with their accessories were the first of their type to be installed in the City of Chicago, an effort was made to obtain all possible data on the performance, even including the drop through the inlet, the strainer and the condenser. The contractors guaranteed that each pumping unit would develop a duty of not less than 129,000,000 ft.-lb. of work per 1000 lb. of steam of quality not less than 98 per cent. dry when pumping at the rate of 30,000,000 gal. of water per 24 hours against a head of 140 ft., not including friction heads through the pump and through the suction and discharge piping between the suction and discharge pressure gages. The steam was to be supplied at the turbine throttle at a gage pressure of 175 lb. per square inch.

As the two units were duplicates, it was decided to investigate the performances of one pump throughout the entire available range of head and capacity and at different speeds, getting all the information possible regarding the power required for auxiliaries and other data. The tests of the other pump were made only over sufficient range to determine its performance at and near the guarantee conditions. The more elaborate series of tests was conducted on pump No. 2. Twelve runs were made as follows: One 4-hour run at as near the guarantee point as conditions permitted; two 2-hour runs at slightly above and below the guaranteed head respectively; seven 1-hour runs over as wide a range as possible; and two short runs at maximum and minimum heads. Pump No. 1 was tested at three points, one 4-hour run being made at approximately the guarantee point and two 1-hour runs above and below the guarantee point respectively.

A complete summary of the data obtained and the results based thereon are presented in Table II. The results as to capacity, head, speed and duty are also shown graphically in the form of curves, from which are determined the official performances at the guarantee condition.

On account of operating conditions it was impossible to provide steam having the specified characteristics either as to pressure or dryness, so that it was necessary to determine from the results actually obtained equivalent results based on the specified conditions. The specifications provided for a duty correction on the basis of 1 per cent. for each 10 lb. difference in steam pressure actually obtaining on the test and the specified pressure of 175-lb. gage. A duty correction based on the foregoing specification is approximately correct, but it was decided that a more accurate correction could be made on the basis of the ratio of the available heat between the actual limits of pressure and vacuum to the available heat between the limits of specified

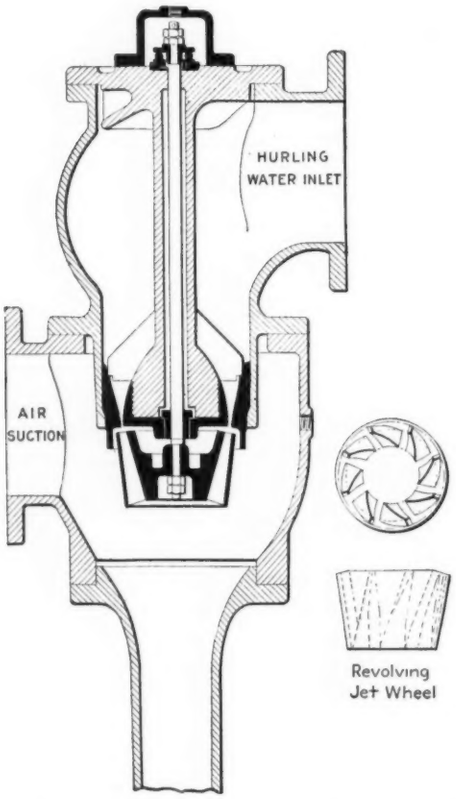


FIG. 3. WORTHINGTON HYDRAULIC VACUUM PUMP

pressure and actual vacuum, assuming that the turbine has the same thermal efficiency, referred to the Rankine cycle, in both cases.

A moisture correction was made on the basis of deducting from the weighed condensate a percentage equal to the difference between 98 per cent. and the actual percentage of dry steam.

To correct for slight variations of speed from a selected standard, the capacity was assumed to vary directly as the speed and the head as the square of the speed. The over-all efficiency of the turbine and pump was assumed to be constant for slight speed variations, consequently the water horsepower varies as the cube of the speed over the ranges in question. For interpolating head-capacity curves over wide ranges of speed, use was made of cross-curves of revolutions and capacity.

In the case of tests near the guaranteed capacity and head, it was found that on account of the low steam pressure there was not sufficient power with the governor valve wide open to drive the pump at the speed necessary for obtaining contract conditions, unless the bypass was used. It was therefore necessary to derive from the data obtained what would have been performed had the steam pressure been as specified; that is, determine the limiting speed corresponding to the specified steam pressure, and at the required head of 140 ft. determine the corresponding capacity and duty.

Correction was made on the assumption that the power of the turbine and also the water horsepower

TABLE I. PRINCIPAL DATA OF MAIN PUMPING UNITS

Main Pumping Unit:	
Length over all, ft. and in	25–6
Width over all, ft. and in	7–1
Height over all, ft. and in	7–6
Total weight of unit, lb	64,000
Total weight of sole plate for entire unit, lb	15,000
Centrifugal Pump:	
Make of pump	Worthington Pump and Machinery Corp.
Normal speed of pump, r.p.m	720
Diameter of shaft at impeller, in	5.5
Diameter and length of each bearing bushing, in	5x13
Total projected area of pump bearings, sq.in	130
Average unit pressure in pounds per square inch on bearings when operating under normal conditions	15.5
Length of pump shaft center to center of bearings, in	84
Diameter of suction inlet, in	36
Diameter of discharge outlet, in	30
Net weight of pump without sole plate, lb	20,200
Steam Turbine:	
Make of turbine	Kerr "Economy"
Brake horsepower of turbine	913
Speed of turbine (normal), r.p.m	3,740
Diameter of steam admission, in	5
Diameter of exhaust, in	36
Net weight of turbine without sole plate, lb	18,000
Reduction Gears:	
Make of gear	Kerr "Economy"
Type of teeth and pitch of teeth, in. involute	20
Pitch diameter of driven gear, in	26.824
Pitch diameter of driving pinion, in	5.176
Total width of face, in	25
Net weight of reduction gear complete, lb	10,000
Gear ratio	5.182 to 1
Mechanical efficiency of gear, per cent	98.8
Horsepower consumed by gears operating under normal conditions	11

would vary directly with the absolute pressure on the nozzles or, what is nearly the same thing, with the initial pressure at the throttle, when the governor valve is wide open. While not absolutely correct, this assumption gave closely approximate results within the narrow limits of steam pressure where it was applied.

As an illustration of the correction take run 3 on pump No. 2. From Table II the data obtained were as follows:

Atmospheric pressure, lb	14.5
Steam pressure, abs., lb	175.2
Vacuum temperature, deg. F	66.25
R.p.m. of pump	710.6
Capacity, m.g.d	26.42
Head, ft. of water	153.1
Duty, based on 98 per cent. dry steam, millions	124.7

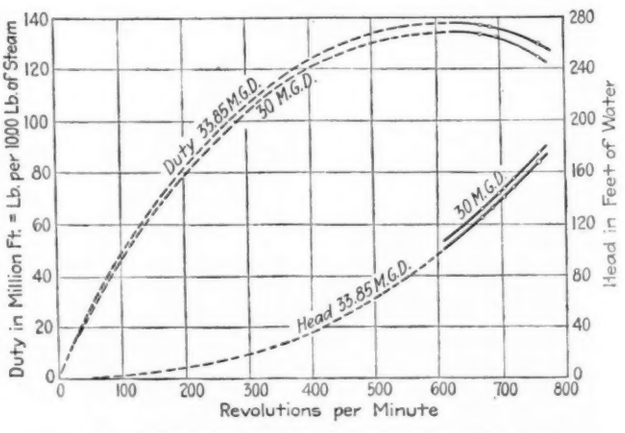


FIG. 4. SHOWING CROSS CURVES FOR UNIT NO. 2

TABLE II. DATA AND RESULTS FROM OFFICIAL DUTY TESTS OF THE TWO PUMPS

		UNIT No. 2												UNIT No. 1		
1	Run number	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
2	Date, December, 1916	14	14	14	15	15	15	15	15	15	15	16	15	21	21	21
3	Interval	2:30 P.-4:30 P	5:00 P.-9:00 P.	9:20 P.-11:20 P.	9:40 A.-10:40 A.	11:30 A.-2:30 P.	1:20 P.-2:20 P.	2:45 P.-3:45 P.	4:10 P.-5:10 P.	5:30 P.-6:30 P.	7:30 P.-8:30 P.			10:40 A.-11:40 A.	1:40 P.-5:40 P.	6:50 P.-7:50 P.
4	Atmospheric pressure, in. of mercury at 32 deg. F	29.50	29.48	29.43	29.03	29.01	29.04	29.08	29.10	29.16	29.22	.....	.....	29.40	29.35	29.40
5	Steam pressure, gage, lb. per sq.in	162.0	161.3	160.7	165.8	161.6	160.9	158.8	162.4	164.3	164.1	.....	.....	166.1	165.7	166.6
6	Steam pressure, absolute, lb. per sq. in	176.5	175.8	175.2	180.1	175.8	175.2	173.1	176.7	178.6	178.4	.....	.....	180.5	180.1	181.0
7	Nozzle pressure, gage, lb. per sq.in	160.2	159.8	159.4	134.1	136.9	146.6	127.1	151.4	139.3	127.2	.....	.....	161.4	160.2	158.8
8	Nozzle pressure, absolute, lb. per sq.in	174.7	174.3	173.9	148.4	151.1	160.8	141.4	165.7	153.6	141.5	.....	.....	175.8	174.6	173.2
9	Temperature of steam at calorimeter, deg. F	371.5	371.2	370.9	373.2	371.2	370.9	369.9	371.6	372.5	372.4	.....	.....	373.4	373.2	373.6
10	Temperature of steam in calorimeter, deg. F	250.4	251.6	252.6	248.8	230.9	230.6	240.0	248.6	252.5	252.9	.....	.....	253.9	256.6	256.6
11	Vacuum, exhaust outlet of turbine, in. of mercury, uncor	28.92	28.89	28.84	28.47	28.14	28.15	28.29	28.57	28.65	28.73	.....	.....	28.76	28.80	28.80
12	Temperature of mercury column for No. 11, deg. F	53.9	55.1	54.6	55.4	57.1	55.7	56.0	56.2	55.9	55.1	.....	.....	53.2	56.1	58.2
13	Vacuum, exhaust outlet of turbine, in. of mercury, cor	28.84	28.80	28.75	28.38	28.05	28.06	28.20	28.48	28.56	28.64	.....	.....	28.68	28.71	28.70
14	Vacuum condenser, air pump end, in. of mercury, uncor	29.07	29.04	29.10	28.66	28.59	28.61	28.68	28.84	28.91	28.95	.....	.....	28.85	28.86	28.92
15	Temperature of mercury column for No. 14, deg. F	53.1	59.8	60.0	61.6	62.3	60.6	60.2	60.2	59.1	59.4	.....	.....	54.1	56.0	57.8
16	Vacuum, condenser, in. of mercury, cor	28.97	28.94	29.00	28.55	28.48	28.50	28.58	28.74	28.81	28.85	.....	.....	28.76	28.77	28.82
17	Vacuum, lb. per sq.in	14.22	14.20	14.24	14.02	13.98	13.98	14.03	14.11	14.15	14.16	.....	.....	14.12	14.12	14.15
18	Back pressure, absolute, lb. per sq.in	0.318	0.318	0.319	0.295	0.431	0.459	0.409	0.298	0.280	0.265	.....	.....	0.330	0.324	0.320
19	Loss in expansion joint of exhaust pipe, in. of water	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	0.320	0.314	0.365
20	Exhaust-pipe loss, in. of water	0.382	0.374	0.374	0.331	0.552	0.586	0.493	0.340	0.326	0.297	.....	.....	0.450	0.435	0.501
21	Condenser loss, in. of water	3.81	3.70	3.57	2.76	6.20	6.58	5.25	3.64	3.08	2.64	.....	.....	1.50	1.51	1.72
22	Temperature corresponding to vacuum, deg. F	66.70	67.60	67.60	65.30	78.00	78.47	75.23	65.00	64.00	63.00	.....	.....	69.24	65.82	68.42
23	Temperature of exhaust, actual, deg. F	66.20	66.18	66.25	64.00	75.15	77.04	73.60	64.27	62.54	60.99	.....	77.00	67.28	66.70	66.36
24	Temperature of condensate, deg. F	53.0	53.0	53.0	53.0	57.0	58.0	58.0	50.0	50.0	50.0	.....	.....	36.0	36.5	37.0
25	Condensate from turbine, including leakage, lb. per hour	11,611	11,613	11,505	10,224	15,719	16,734	14,749	10,900	10,150	9,389	.....	.....	11,218	11,050	11,017
26	Condenser leakage, lb. per hour	97	97	97	97	97	97	97	97	97	97	.....	.....	99	99	99
27	Quality of steam, per cent. dry	96.75	96.83	96.89	96.64	95.69	95.67	96.23	96.67	96.85	96.88	.....	.....	96.91	97.07	97.05
28	Net condensate, 98 per cent. dry, lb. per hour	11,367	11,378	11,279	9,986	15,254	16,241	14,387	10,656	9,935	9,135	.....	.....	10,995	10,847	10,812
29	Elevation of lake at crib, feet ± Chicago datum	+0.10	+0.16	+0.15	+0.09	+0.29	+0.42	+0.33	+0.36	+0.42	+0.25	.....	.....	+0.33	+0.50	+0.70
30	Elevation of water in suction well, feet ± Chicago datum	—1.39	—1.17	—1.03	—1.29	—1.46	—1.21	—0.85	—1.15	—1.04	—0.94	.....	.....	—0.80	—0.63	—0.93
31	Loss through tunnel, feet of water	1.49	1.33	1.18	1.32	1.75	1.63	1.18	1.51	1.46	1.19	.....	.....	1.11	1.13	1.63
32	Loss of head through entrance, feet of water	0.07	0.03	0.02	0.03	0.11	0.05	0.06	0.07	0.03	0.03	.....	.....	0.30	0.17	0.11
33	Loss of head through strainer, feet of water	1.46	1.07	0.76	0.35	1.78	1.51	0.88	1.43	0.89	0.58	.....	.....	1.40	0.94	0.65
34	Loss of head through condenser, feet of water	0.37	0.28	0.22	0.10	0.35	0.30	0.21	0.37	0.25	0.17	.....	.....	0.19	0.10	0.07
35	Mercury column on discharge, cor., feet of mercury	8.250	9.972	11.120	12.106	8.253	11.240	.....	.....	9.528	10.252	.....	.....	8.074	9.939	11.240
36	Elevation of zero of mercury column, feet ± Chicago datum	0	0	0	0	0	0	.....	.....	0	0	.....	.....	0.055	0.055	0.055
37	Temperature of mercury in mercury column, deg. F	60.0	61.2	62.0	66.9	65.9	63.7	.....	.....	63.0	63.0	.....	.....	65.0	64.2	66.2
38	Discharge head, feet of water	112.03	135.42	151.01	164.41	112.07	152.65	172.67	108.66	129.40	139.25	90.15	179.02	109.59	134.92	152.60
39	Discharge press. as shown by Bourdon gage el. + 1.149, lb. per sq.in	48.22	58.35	65.10	71.17	48.30	65.56	74.25	46.54	55.90	60.20	38.53	77.0	46.14	58.14	65.64
40	Suction head taken above entrance, feet below datum	1.76	1.41	1.20	1.32	1.93	1.57	1.08	1.51	1.24	1.07	0.96	0.0	1.39	1.03	1.16
41	Velocity head in discharge pipe, feet of water	2.15	1.53	1.07	0.44	2.68	2.27	1.25	2.10	1.20	0.72	2.52	0.0	2.10	1.36	0.93
42	Velocity head in suction pipe, feet of water	0.30	0.21	0.15	0.06	0.36	0.31	0.17	0.29	0.17	0.10	0.34	0.0	0.29	0.19	0.12
43	Net velocity head, feet of water	1.85	1.32	0.92	0.38	2.32	1.96	1.08	1.81	1.03	0.62	2.18	0.0	1.81	1.17	0.81
44	Test head, feet of water	115.64	138.15	153.13	166.11	116.32	156.18	174.83	111.98	131.67	140.94	93.29	179.02	112.79	137.13	154.55
45	Temperature of water pumped, before condenser, deg. F	35.0	34.5	34.2	33.3	33.0	33.0	33.0	33.0	32.9	32.5	.....	.....	32.5	32.0	32.0
46	Temperature of water pumped at suction inlet to pump, deg. F	.....	.....	.....	.....	.....	.....	34.5	33.8	33.8	33.6	.....	.....	33.3	33.6	33.7
47	Temperature of water pumped in discharge (hurling water), deg. F	36.0	35.8	35.8	35.3	34.5	34.6	34.9	34.0	34.1	34.0	.....	.....	33.3	33.3	33.5
48	Temperature of water discharged by air pump, deg. F	36.9	36.6	36.5	36.1	35.6	35.3	35.8	34.7	34.7	34.6	.....	.....	33.3	33.6	33.7
49	Water pumped to service mains, million gal. per 24 hours	37.37	31.53	26.42	17.00	41.61	38.31	28.51	36.79	27.96	21.30	40.15	0.00	36.88	29.60	24.32
50	Water horsepower obtained	758.9	764.9	710.4	495.9	849.9	1,050.7	875.3	723.4	646.5	527.2	657.7	0.00	730.0	712.8	660.0
51	Duty per 1000 lb. of steam as tested 98 per cent. dry, million ft.-lb	132.2	133.1	124.7	98.3	109.8	128.1	120.5	134.4	128.8	113.6	.....	.....	131.5	130.1	120.8
52	Duty per 1000 lb. of steam cor. to 175 lb. gage, 98 per cent. dry, as specified	133.9	134.9	126.5	99.2	111.3	129.9	122.4	136.1	130.2	114.9	.....	.....	132.7	131.3	121.8
53	Duty per 1000 lb. of steam cor. to 175 lb. gage, 98 per cent. dry, actual	133.7	134.7	126.4	99.1	111.2	130.1	121.9	135.7	130.0	114.7	.....	.....	132.5	131.6	121.7
54	Oil temperature leaving gears, deg. F	138.5	141.1	142.4	143.5	145.5	147.9	147.6	140.0	137.6	136.9	.....	.....	146.0	147.1	148.5
55	Temperature of incoming oil to cooler, deg. F	123.0	125.9	127.0	127.2	128.2	130.5	129.9	124.8	121.9	120.6	.....	.....	127.2	128.0	129.0
56	Temperature of outgoing oil from cooler, deg. F	112.9	115.1	116.0	118.0	118.0	120.0	120.0	114.0	109.8	108.0	.....	.....	111.6	112.9	113.9
57	Pelton wheel nozzle pressure, lb. per sq.in	47.6	47.4	65.2	70.5	46.8	63.5	72.8	45.7	54.7	59.5	.....	.....	46.7	57.5	65.5
58	Air pump hurling water pressure, lb. per sq.in	38.5	39.2	38.0	38.2	39.0	38.5	38.4	38.2	38.5	39.1	.....	.....	38.5	38.4	40.0
59	Water used by Pelton wheel, gal. per min	60.1	53.8	50.4	47.8	80.0	76.3	58.1	54.9	47.8	45.5	.....	.....	.....	.....	.....
60	Water used by air pump, gal. per min	388	384	384	384	384	384	384	384	384	384	.....	.....	.....	.....	.....
61	Revolutions per minute, main pump	6,819	691.6	710.6	720.7	758.6	767.9	760.3	667.7	665.0	670.6	688.0	718.0	683.5	699.8	713.4
62	Revolutions per minute, turbine	3,546	3,596	3,695	3,748	3,948	3,993	3,954	3,472	3,458	3,487	3,578	3,734	3,554	3,639	3,710
63	Total water pumped by main pump, million gal. per 24 hours	38.02	32.16	27.05	17.62	42.28	38.97	29.15	37.42	28.58	21.92	.....	.....	.....	.....	.....
64	Total water horsepower obtained	770.0	780.2	727.4	514.0	863.6	1,068.8	894.9	735.8	660.8	542.5	.....	.....	.....	.....	.....
65	Steam equiv. required for aux., lb. per hour	193.0	223.1	263.6	351.6	242.0	275.0	315.1	179.5	215.0	257.6	.....	.....	.....	.....	.....
66	Corrected duty per 1000 lb. steam based on total pumpage	135.9	137.3	129.2	102.7	113.5	131.9	125.0	138.1	132.9	118.6	.....	.....	.....	.....	.....
67	Per cent. of power required by auxiliaries	1.70	1.96	2.34	3.52	1.59	1.69	2.19	1.68	2.16	2.82	.....	.....	.....	.....	.....

The duty corrected to the specified pressure of 175 lb. gage, or 175 + 14.5 = 189.5 lb. abs., and 98 per cent. dry steam is calculated as follows:

$$\frac{Duty}{124.7} = \frac{H_1 - H_3 + T_3(N_3 - N_1)}{H_2 - H_3 + T_3(N_3 - N_2)}$$

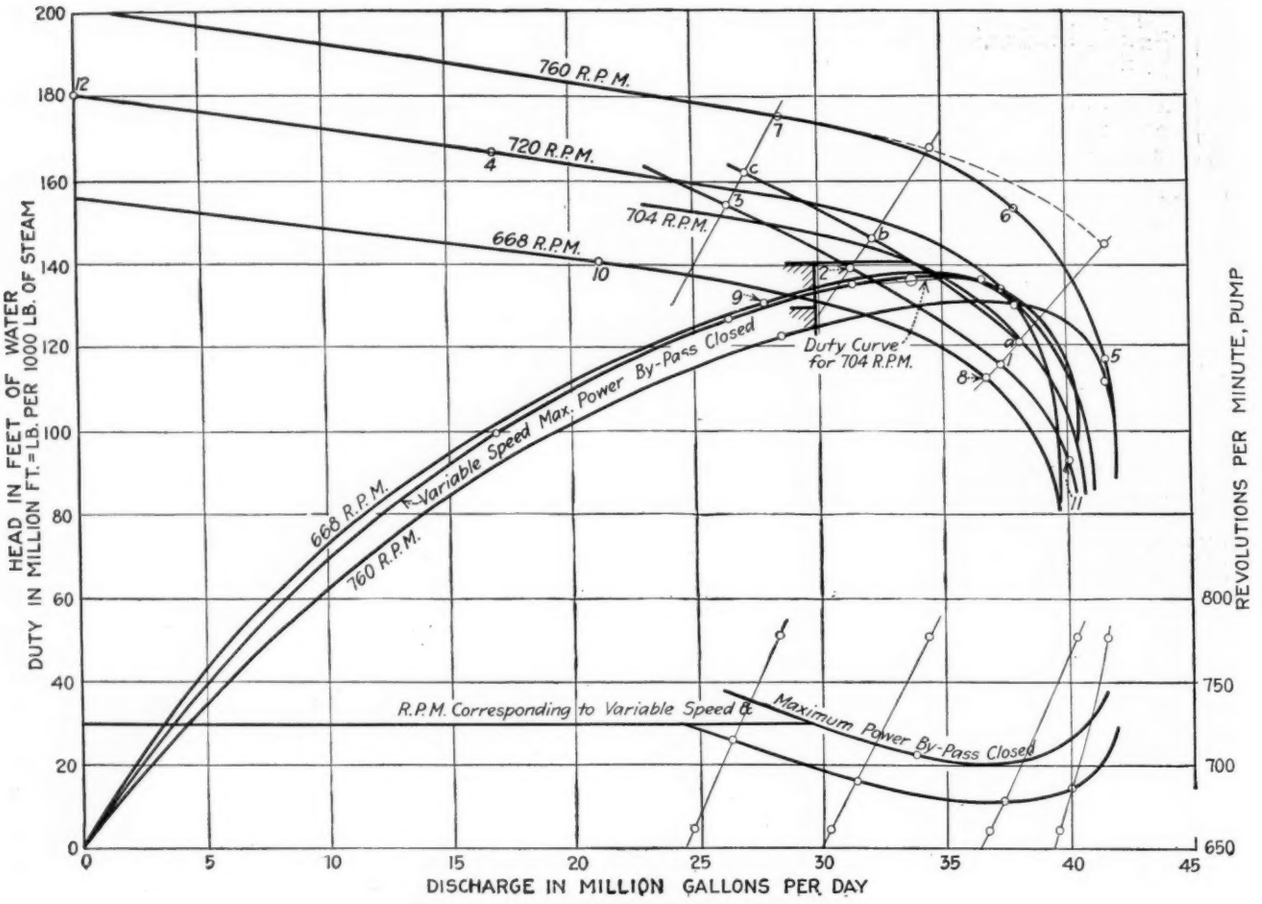

760 R.P.M.
720 R.P.M.
704 R.P.M.
668 R.P.M.
Duty Curve for 704 R.P.M.
Variable Speed Max. Power By-Pass Closed
668 R.P.M.
760 R.P.M.
R.P.M. Corresponding to Variable Speed & Maximum Power By-Pass Closed
HEAD IN FEET OF WATER
DUTY IN MILLION FT.-LB. PER 1000 LB. OF STEAM
REVOLUTIONS PER MINUTE, PUMP
DISCHARGE IN MILLION GALLONS PER DAY

FIG. 5. CHARACTERISTICS OF UNIT NO. 2

H_1 = Total heat at 189.5 lb. abs. (98 per cent.) = 1180.4;
H_3 = Total heat at 66.25 deg. F. = 1088.6;
T_3 = Abs. temp. exhaust = 459.6 + 66.25 = 525.8;
N_3 = Entropy at 66.25 deg. F. = 2.0724;
N_1 = Entropy at 189.5 lb. abs. (98 per cent. dry) = 1.5298;
H_2 = Total heat at 175.2 lb. abs. (98 per cent. dry) = 1178.8;
N_2 = Entropy at 175.2 lb. abs. = 1.5361.

Hence the corrected duty is 126.4 millions.

On this run the governor was wide open and the turbine delivered its maximum power for the given steam pressure, the water horsepower obtained being 705. The water horsepower available with the specified steam pressure is $\frac{705 \times 189.5}{175.2} = 762$.

The capacity varies directly as the speed and the head as the square of the speed; hence,

$$Corrected\ capacity = 26.42 \times \left(\frac{762}{705}\right)^{\frac{1}{2}} = 27.10\ m.g.d.$$

$$Corrected\ head = 153.1 \times \frac{762^{\frac{1}{2}}}{705} = 161.3\ ft.$$

On the curve sheet, Fig. 5, this point is plotted at *c*. The points corresponding to runs Nos. 1 and 2 are plotted at *a* and *b* respectively. A curve through points *a*, *b* and *c* is a head-capacity curve representing the output that would have been obtained with the specified steam pressure. Hence at the specified head of 140 ft., the capacity would be 33,850,000 gal. per day. From the cross-curves, Fig. 4, it is seen that the corresponding revolutions per minute are 704. The duty at this point is obtained from an interpolated duty curve corresponding to 704 r.p.m., the interpolation being based on a cross-curve at 33.85 m.g.d., as abscissas and duties as ordinates. Hence the corrected duty is 135 millions, an exceptionally high figure considering the size of the pump and the operating conditions. In addition to the usual heads, duty and horsepower data it will be noticed that Table II contains other interesting data such as percentage of power required by the auxiliaries, the loss of vacuum in the condenser and exhaust pipe and the loss of head through the en-

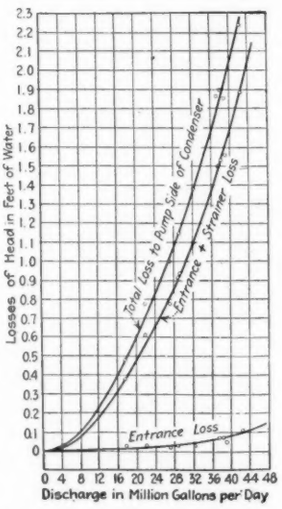

Losses of Head in Feet of Water
Total Loss to Pump Side of Condenser
Entrance + Strainer Loss
Entrance Loss
Discharge in Million Gallons per Day

FIG. 6. SUCTION LOSSES CORRECTED FOR VELOCITY HEADS

trance to the suction line, through the strainer and the condenser. The method of obtaining these drops in the water end of the installation was unique and unusually convenient. Manometer connections were made before and after the suction inlet of the pump, between the strainer and condenser, and after the condenser. Instead of reading the manometers near the points of attachment, all connections were brought up to a common board on the first-floor level, Fig. 7. Tubes from the four attachments just mentioned and a mercury column were connected to a common header at the top of the board, with shut-off valves just below the header. The latter was connected to the condenser, and by opening the valve in the header sufficient vacuum was created to draw the water up into the tubes as high as the board, the small valves in the tubes being left full open. When the water appeared in the glass tubes, the header valve was closed and only had to be cracked occasionally to maintain the vacuum, as there was very little air leakage. Cross-section paper marked off to give distances above the city datum was placed behind the tubes, and by reading the differences in water levels between the various tubes the drop between any two points was determined directly in feet. The scale back of the mercury column in conjunction with the manometer to the suction well enabled a determination to be made of the elevation of the water in the suction well.

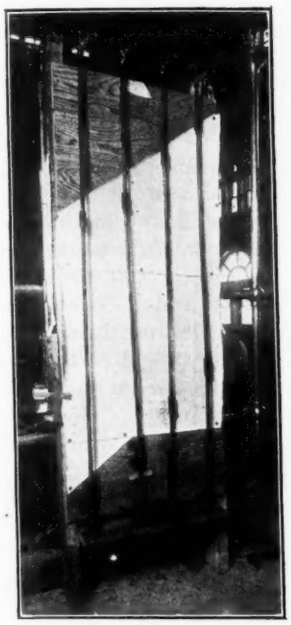


FIG. 7. MANOMETER BOARD

Fig. 6 gives the suction losses corrected for velocity heads, as determined by these readings. At the prescribed capacity of 30,000,000 gal. per 24 hours the entrance loss was about 0.04 ft. of water, the strainer loss about 0.92 ft. and the drop through the condenser about 0.24 foot.

In the tests William A. Nelson represented the city and R. W. Allerton the contractor's interests. C. J. Bacon was the third expert.

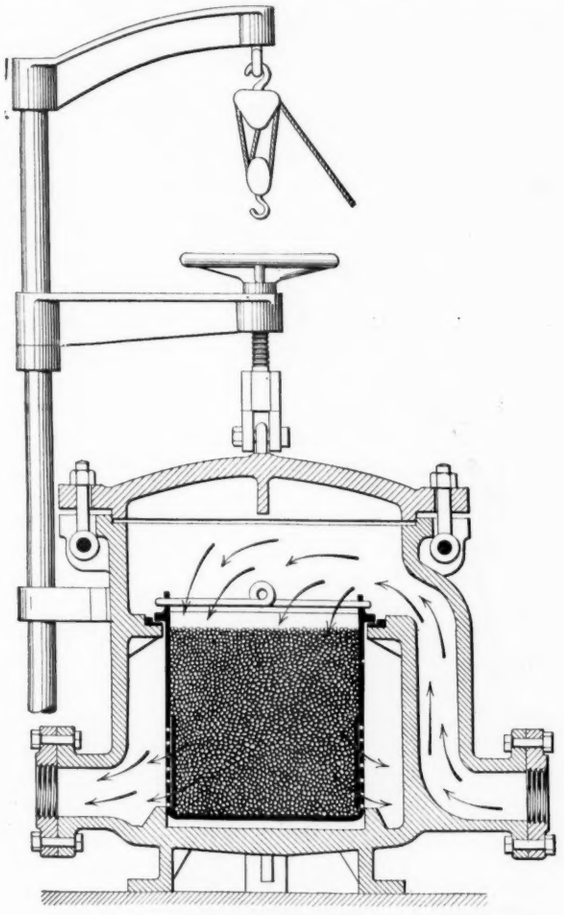
Increased Exports of Mineral Oils

Mineral oils exported from the United States during the fiscal year 1917 ammounted to 2,749,438,434 gal. valued at $230,953,149, according to figures made public by the Department of Commerce. This was an increase of approximately 300,000,000 gal. and $65,000,000 over 1916 and about 470,000,000 gal. and $79,000,000 over 1914, the last normal year before the war. Only a small percentage of the total exported was crude oil.

The war has had the effect of reducing the exports of illuminating oil, the foreign sales for 1917 totaling 835,114,403 gal. valued at $54,662,094, against 1,157,283,310 gal. valued at $74,500,162 in 1914. Exports of gas and fuel oil, however, have more than doubled in quantity and value in the last three years, increasing from 475,143,205 gal. valued at $13,747,863 in 1914 to 1,040,671,713 gal. valued at $32,473,872 in 1917. The exports of gasoline and lubricating oils have also increased substantially.

Detroit Pressure Filter

A feed-water filter that has been designed to remove the scale-making material from boiler-feed water before it goes into the boiler is known as the Detroit pressure filter, and is made by the Detroit Steam Appliance Co., Union Trust Building, Detroit, Mich. The outside housing is made of cast iron and steel, with a 4-in. inlet and outlet which can be reduced with flanged fittings. The filter basket is of brass. As the cover plate is held in place by eye-bolts, it is easily removed



SECTION THROUGH FILTER AND BASKET

by means of a hand-screw that is attached to the arm. When it is desirable to remove the filter basket, a rope and tackle is used.

The basket is filled with filtering material which can be emptied out when it becomes dirty, washed and used again. As shown by the arrows in the illustration, the course of the water is down through the filtering material and through perforations in the bottom half of the filter basket. The plan is to feed a chemical in the heater where the scale-making salts are precipitated, and the partly purified water is then pumped through the filter, to remove them before the water enters the boiler.

Water Gages on Marine Boilers

By W. M. McROBERT

Describes the several types of water columns and gages used on marine boilers and points out where and how they will give trouble.

IN THE near future the position of a marine engineer will rise to a much higher level than heretofore because the demand for capable men will be much in excess of the supply.

Previous to the war the engineer aboard ship was looked upon as being just a little inferior in rank to the deck officer, but this condition has now been reversed and shipping companies find it much more difficult to secure good engineers than navigators. Marine engineering is somewhat different from stationary engineering, and a marine man is practically entirely dependent on his own resources. He has not, in the event of a breakdown, a machine shop, modern tools and repair staff at his disposal. He has at times to undertake hazardous and difficult work under unique conditions and often with crude appliances. The word "can't" has to be eliminated from his vocabulary and replaced by grit and determination.

Thoroughness and care in all work and duties performed are essential. If a mistake is made, as anyone will occasionally, however serious it may be it should be reported at once to the right source, as it will likely prevent further accidents and complications to do so. Did it ever occur to the reader how the large ocean mail liners can year after year arrive at their destinations practically as regularly as most trains and in almost any kind of weather? To the engineer this is indicative of how thorough must be the work of the marine engineer.

Even should a young engineer not permanently adopt marine service, he will find that a few years spent on an ocean steamer will serve him with experience that should prove invaluable to him all his life, both in practice and theory.

Notwithstanding that most examiners of applicants for marine engineers' licenses make a special feature of the water gage, numerous boiler accidents and explosions occur either from engineers not being familiar with the construction of the water gage or not satisfying themselves by actual test that the cocks, pipes and connections to the boiler are clear.

The writer recalls one instance in his experience where a "donkey" (an auxiliary) boiler was practically ruined owing to a misunderstanding among engineers, who may be called, for convenience, Nos. 1, 2 and 3. It was the night before leaving port, and steam was being raised on the main boilers preparatory to proceeding on a voyage to Australia. The auxiliaries, including cranes, light engines, pumps, etc., were being supplied with steam from the donkey boiler, which would be in use only for a short while before changing over to the main units. Engineer No. 1 was about to go off watch and before doing so "pumped up" the donkey boiler; but during the time this operation was in progress he had other duties to attend to, with the result that he allowed too much water to get in the boiler. The gage showed more than a full glass.

The feed pump which was used while in port to supply the donkey boiler with water was not required when at sea, and engineer No. 1, knowing that he had put too much in the boiler, came to the conclusion that the pump would not be further required and closed the cock on top of the boiler which controlled the steam supply to the pump. This cock was located near cock *A*, Fig. 3. Engineer No. 2 now came on watch, and No. 1 mentioned to him that he had pumped "a little too much" water into the boiler, but added that it would soon be all right. After being an hour on watch No. 2 still found the glass full and frequently blowing through by means of cock *E*, Fig. 3; water still issued forth, and he naturally expected that No. 1 must have pumped a lot more water into the boiler than he reported. However, No. 2 thought he would "wait a bit"; but after three hours the glass still showed full, and he then decided to blow water out of the boiler until the water level in the glass could be determined, but even after doing so the gage still showed full.

Engineer No. 3 next came on watch and after thoroughly blowing the glass by means of cock *E*, Fig. 3, and learning the account of No. 2, he began to investigate and on going on top of the boiler found that cock *A* was shut. On opening it the water in the glass disappeared. He then thoroughly tested the gage by means of the cock *T*, and on opening it only dry steam issued. It was found that Engineer No. 1, when shutting off the steam supply to the feed pump as he supposed, had by mistake closed cock *A* which controlled the pump steam line.

Many steamers have had similar experiences through false water level, and on examination it has been proved on nearly every occasion that the cocks or connections to the steam and water spaces were closed or choked. This cannot really be attributed to accident, but to lack of care or to bad management.

Unless an engineer is able to prove that he is thoroughly acquainted with the water gage and able to test its veracity in every way, he should on no account be left in charge of a marine or any other type of boiler. The writer does not favor globe valves on water-gage connections; straightway cocks are most reliable.

Figs. 1, 2, 3, 4 and 5 serve to illustrate the most usual methods of attaching gage mountings to marine boilers. Figs. 1 and 2 are not to be recommended, although on the old type of boilers they are sometimes found.

The principal features of each gage and the method of proving the correctness of the water level are separately dealt with in the following.

Referring to Fig. 1: It will be seen that the gages are screwed into the boiler front head. They may be tested as follows: First let *B* remain open, then close *D* and open *E*, and if steam issues it shows that *B* and the passage leading to it are clear. Should no steam or water issue, either cock *B* or the passage leading to it is choked and must be cleared. Second, close *B* and open *D* and *E*, and if water issues *D* and the passage leading to it are clear.

Referring to Fig. 2: In this case the gage-cocks are attached to a bent pipe of about 3 in. internal diameter, the top end communicating with the steam space and the lower with the water space of the boiler. The large pipe is not likely to become choked and is superior to the design shown in Fig. 1. The gage can be tested in practically the same manner as Fig. 1. Removable plugs are fitted at *AA* and *BB*, by which the openings may be cleared when necessary by means of a rod or wire, when the boiler is not under steam.

Referring to Fig. 3: In this design there is a clear opening from *A* to *C* through the column *Y*, and to "blow through the glass" it is only necessary to shut cocks *D* and *B* alternately, keeping *E* open. But to "blow through the water gage," including the pipes *H* and *I*, it is necessary, after blowing through the glass as described, to shut *A* and *C* alternately, at the same time keeping *B*, *D* and *E* open for sufficient time to completely discharge the contents of the gage and its connections.

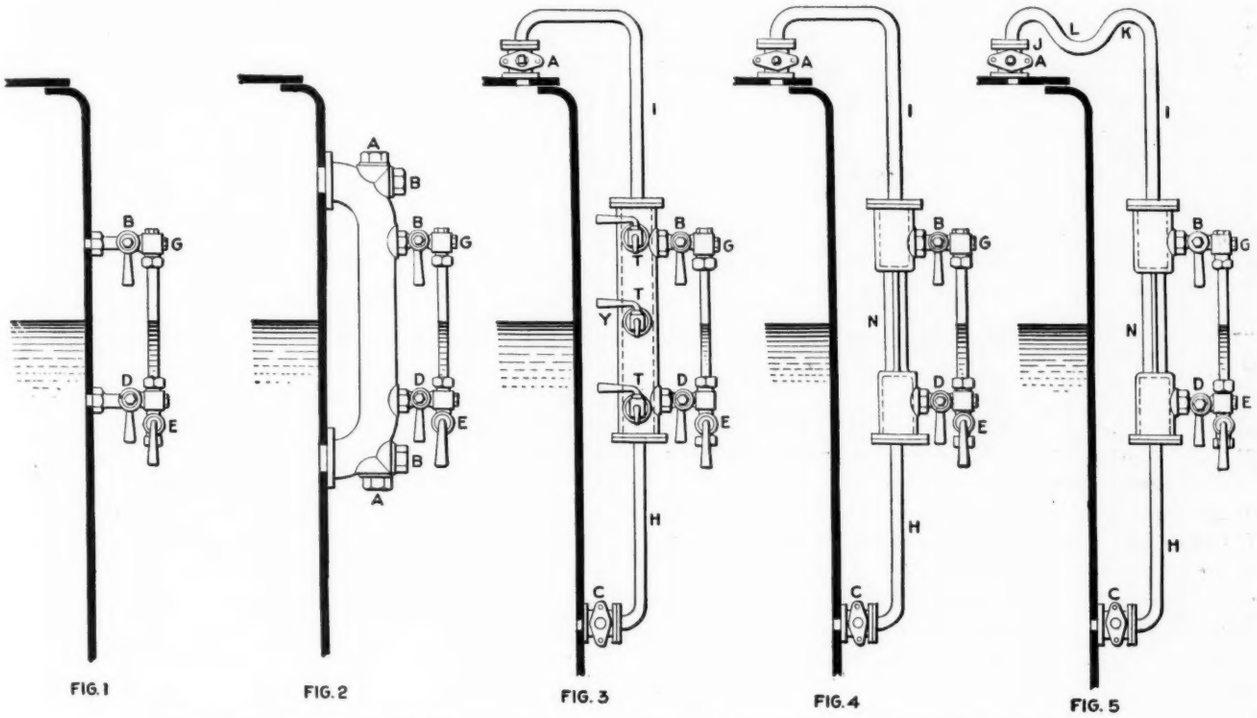
When *B*, *D* and *C* are clear and *A* choked, the steam remaining in the glass and in the pipe *I* leading from column *Y* to *A* becomes condensed and the water flowing through *C* to take its place rises in column *Y*, also in the glass to a level above that of the water in the boiler. In other words, the gage shows a false water level.

If cock *E* be now opened and water is blown out, then on *E* being again closed the water in the gage will rise higher than before, and be still further misleading. On the other hand, when *B*, *D* and *A* are clear and *C* choked, the water, if any, in the glass is trapped and no longer rises and falls with the water in the boiler or with the motion of the vessel; it, however, slowly rises in the glass owing to the condensation of the steam in the upper part of the gage, until such time as *E* is opened, when all the water in the glass is blown out, and on *E* being again closed the glass will not show any water, notwithstanding that the water in the boiler may be at the proper level.

When test cocks *T T T* are attached to column *Y*, as shown in Fig. 3, they cease to be reliable when either *A* or *C* or the pipe in connection therewith is choked wholly or nearly so.

Referring to Fig. 4: Sometimes the water-gage fittings are arranged as shown in Figs. 4 and 5 with no passage up the column, the central portion *N* of the column being simply a pillar or connecting piece of any convenient section between the upper and lower portions to which the cocks *B* and *D* are attached. By this arrangement double communications are eliminated and there is no need for what is known as the "double shut-off" in testing the accuracy of the gage. When, however, the gages are constructed in this manner, the cocks *B* and *D* are unreliable as test cocks in the event of there being no glass in the gage. This feature should be carefully noted. Moreover, when in working condition the reduction of pressure in the glass which arises when *E* is opened causes the water in pipe *H* to rise above its normal level. This objectional feature should also be noted.

Referring to Fig. 5: Sometimes due to faulty construction, there may be a bend *L* in the steam pipe *I* leading from cocks *A* to *B*. This has occurred when new boilers have been installed on ships, the bend being caused in an effort to clear other pipes, beams, fittings, etc., located near the smokebox. With such a bend the condensed steam collects in the pipe and falls to the bottom of the bend, and in time completely fills the pipe *J* to *K*. The steam from *K* to the level of the water in the glass is throttled and, as condensation proceeds, leads to a reduction of pressure in the pipe below that of the



FIGS. 1 TO 5. TYPES OF WATER GAGES FOR MARINE BOILERS, SHOWING CONNECTIONS

boiler, with an equivalent rise of the water in the bend and also in the gage-glass. When the ship is not in motion, the water in the gage-glass increases in height until cock *E* is opened, or until the pressure in the boiler is so much in excess of that in the lower part of pipe *I* as to cause the water in the bend to be blown into the gage-glass. In either case immediate change of water level takes place.

In the ordinary course of working, the condition described is modified by the presence of air in the upper part of the gage and by the rise and fall of the water in the boiler and gage-glass arising from the motion of the steamer.

Probably more than half of the steamers afloat are fitted with water gages as shown in Figs. 3 and 4, and it is important that engineers should be especially acquainted with their construction and principle of operation. Cocks *A* and *C* are not necessary for the testing of gages as shown in Figs. 4 and 5. Engineers should note that it is impossible to reliably test water gages as shown in Fig. 3 when the cocks *A* and *C* are absent. They should note the effect which the choking of cock *A* or *C* or pipe *H* or *I* has on the indications of the test cocks *T T T* fitted on column *Y*.

When a gage-glass is too short or is placed either too high or too low in the fittings, it is liable to become choked by the packing being forced over its ends when the gland is being screwed up.

When a gage-glass is too long, it will not permit of a rod being inserted at *G* to allow for cleaning the passage through cock to boiler. This defect would also tend to cause a false water level.

Boiler accidents have occurred from the handles of the cocks not being exactly at right angles to the cock openings, owing to the former being strained and becoming bent or twisted.

Another casualty took place due to the twisting of the stem on cock *A*, Fig. 3, from its original position, resulting in the cock being shut when apparently open. Avoid straining the stem or handle of the cock.

Hot-Water Heating Under Forced Circulation—V*

By Charles D. Allan
Consulting Engineer for the Mechanical Equipment of Buildings, Chicago

Typical central-station layout and detail data on exhaust- and live-steam and combination heaters.

In hot-water heating an entirely different circulating medium, having physical characteristics unlike those of steam, is employed. This medium passes from the source of heat absorption through the system and back without the change in density and physical form that results from condensation in steam heating. Consequently a complete discussion of the subject matter calls for a general description of the mechanical construction and accessories necessary to meet these conditions. In the central plant the circulating water may be heated by steam through the medium of a tubular heater, or by passing directly through a boiler as in ordinary house-heating by hot water. Where there is a steam-power plant and a supply of exhaust steam is available, the former method is employed as a matter of course. Where there is no power plant and electric current is furnished by a public-service corporation, the latter method should be used.

TABLE I. METHOD OF OPERATION (SEE FIG. 1)

Heaters in Service	Position of Valves A	B	C	D	E
Exhaust steam heater only	Open	Closed	Closed	Open	Closed
Live steam heater only	Closed	Open	Closed	Closed	Open
Both heaters in parallel	Open	Open	Closed	Open	Open
Both heaters in series	Open	Closed	Open	Closed	Open

Fig. 1 illustrates a typical central-station arrangement where there is a steam-power plant and steam is used to heat the water of circulation. Two heaters are employed, one designed for the use of exhaust steam at atmospheric pressure and the other for live steam at boiler pressure, the latter to be used when the supply of exhaust steam is inadequate or entirely lacking.

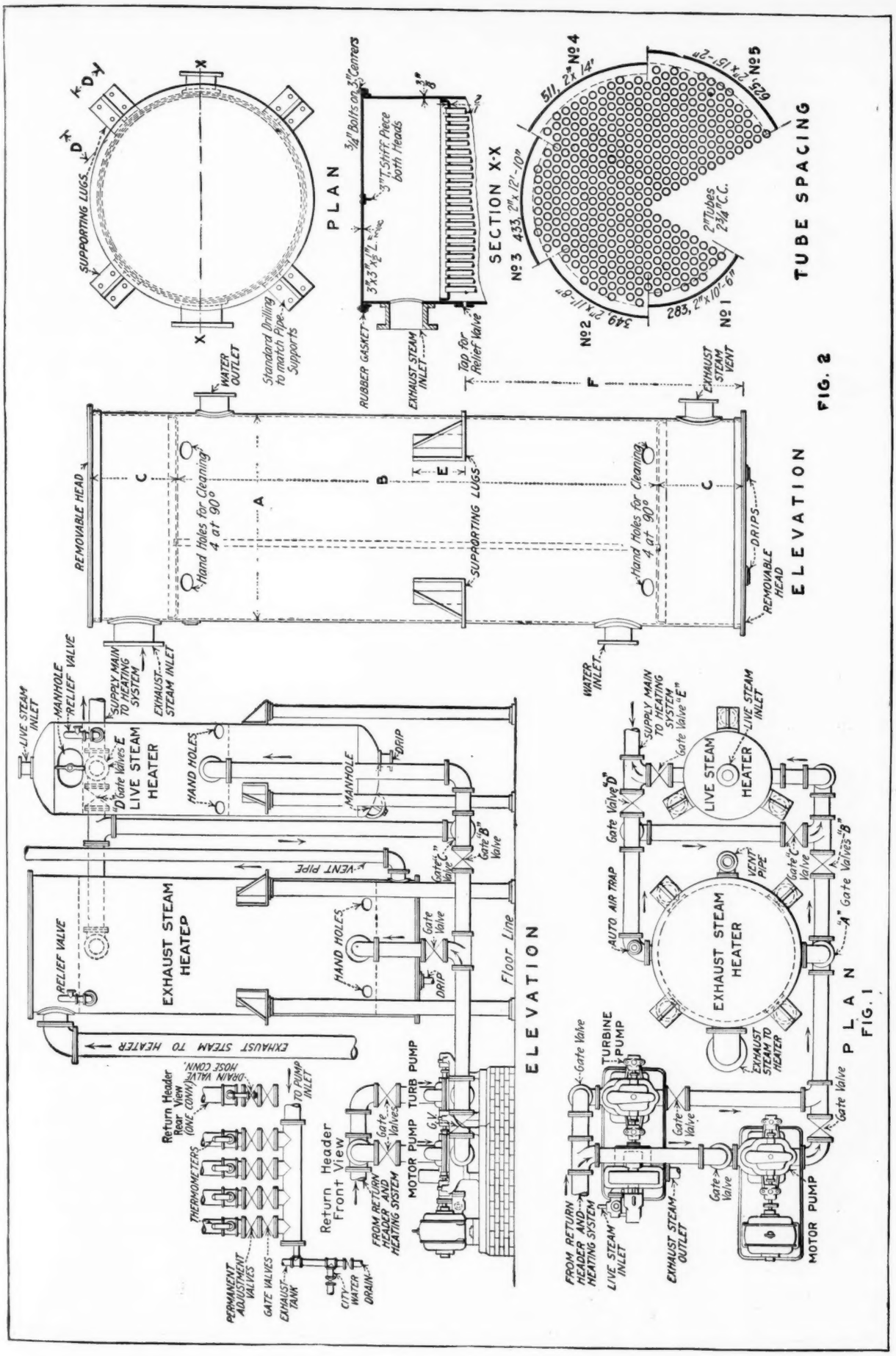
In most cases two circulating pumps are used as shown, the electric pump being employed while the power plant is in operation and the steam pump at any time that the supply of exhaust steam is insufficient. In the latter case live steam must be used for heating, and the turbine merely acts as a pressure-reducing valve between the live-steam supply line and the low-pressure heater.

The general arrangement of piping, including a return header, is also shown, and the table accompanying the cut shows the arrangement of valves by which the circulating water may be made to pass through either heater alone, both in series or both in parallel. The heaters, pumps, connecting piping, return header and accessories such as thermometers and gages comprise what is collectively known as the "central-station apparatus." Where the circulating water is heated by

TABLE II. DIMENSIONS, HEATING SURFACE, WEIGHT, ETC. (SEE FIG. 2)

No.	Dimensions in Inches A	B	C	D	E	F	Heating Surface No. of 2-In. Tubes	Length B Ft.	In.	Sq.Ft.	B.T.U. per Hr. Stm. 1 Lb. Gage Water 185 Deg. 27x230xSq.Ft.	Average Size Connections Steam Inlet	Steam Vent	Water Drip	Water Both	Water Rel.	Weight in 2,000-Lb. Tons Empty	Full	Lb. per Sq.Ft.	Size Pipe Legs Ex. Heav.
1	54	126	22½	12	18	72	283	10	6	1,486	9,228,060	12	6	3	7	1	5.9	9.1	8.0	5
2	60	140	25	12	18	80	349	11	8	2,036	12,643,560	14	7	3½	8	1	7.7	12.1	7.6	5
3	66	154	27½	12	18	88	433	12	10	2,778	17,251,380	16	8	4	9	1¼	9.8	15.6	7.1	5
4	72	168	30	12	18	96	511	14	0	3,577	22,213,170	18	9	4½	10	1¼	12.1	19.6	6.8	5
5	78	182	32½	12	18	104	625	15	2	4,739	29,429,190	20	10	5	12	1½	15.2	24.6	6.4	5

*Copyrighted, 1917, by Charles D. Allan.



FIGS. 1 AND 2. HEATERS AND PIPING FOR HEATING WATER IN A CENTRAL DISTRIBUTING STATION

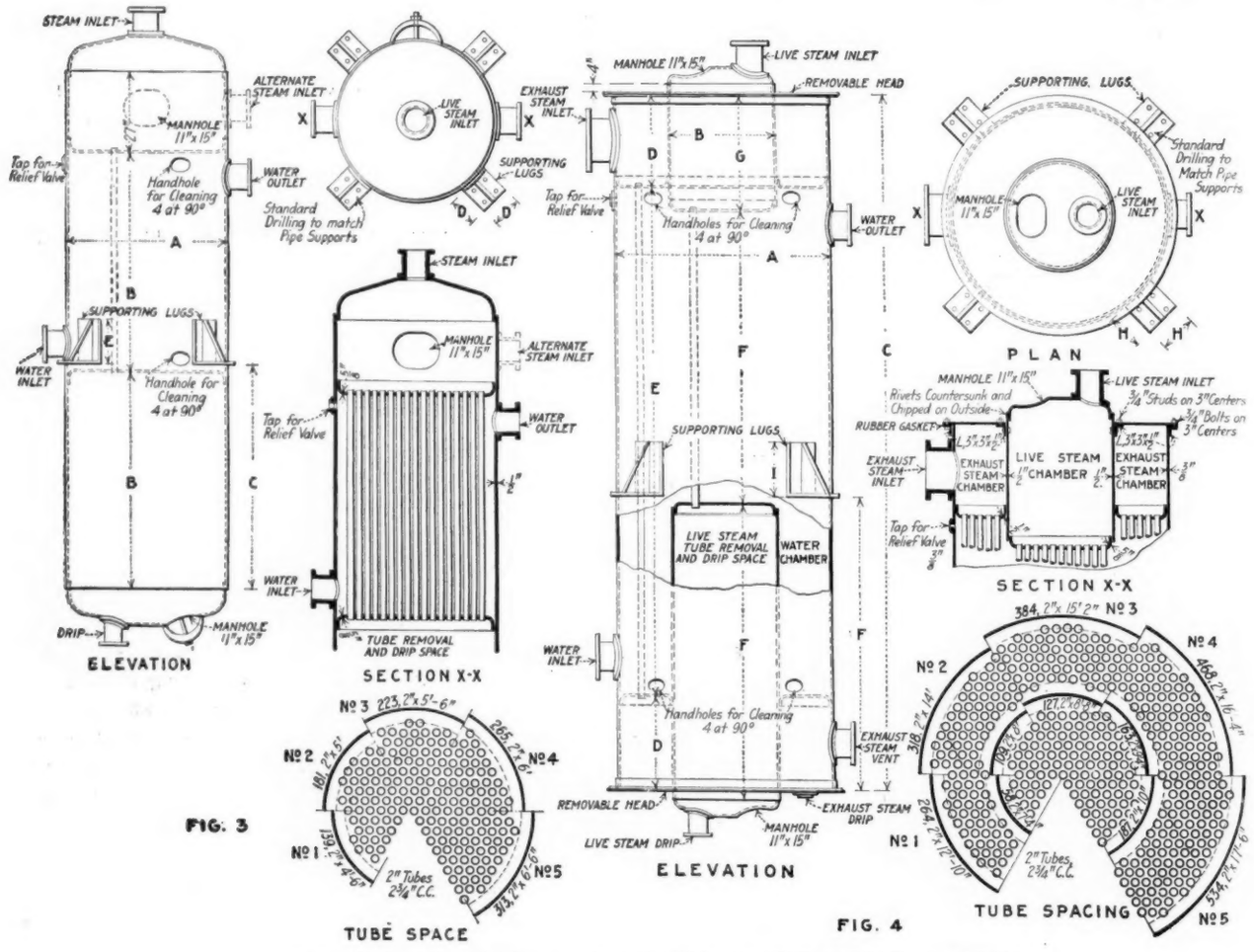
Fig. 1—Typical central-station heater layout. Fig. 2—Details of exhaust-steam heaters

passing directly through the boiler, the latter takes the place of heaters, the general arrangement being substantially the same.

It is self-evident that what is known as the closed type of heater must be used in this work, or in other words, a heater where the steam does not come in direct contact with the circulating water. If the open type commonly employed for heating boiler-feed water were used, the circuit would be broken and the circulating pump would have to lift against the static head to the highest point of the system, as well as the friction head, to say nothing of other complications due to siphonage.

Any good tubular heater may be used for this work, the problem being the same as in ordinary condenser practice, except that the circulating water is higher in temperature and additional tube surface must accordingly be provided to insure a given amount of heat transmission.

Generally speaking, the various standard forms of tubular heaters are more expensive than the conditions call for, as they are almost invariably constructed with brass or copper tubes. The same water is used over and over, and fresh water with fresh impurities having affinity for iron is not introduced in the system in sufficient volume to make brass or copper tubing necessary. On the other hand, there is no objection to copper or brass tubing excepting the first cost, and some engineers prefer this type. The great majority of these plants are provided with heaters in which ordinary 2-in. lap-welded boiler tubing is used. Fig. 2 shows five sizes of exhaust-steam heaters, which will cover all ordinary conditions in actual practice. The cut is self-explanatory, showing all details, including tube spacing, thickness of metal, etc. Accompanying the cut is a table giving all dimensions, number of tubes, heating surface, heat transmission, size of connections, weight, etc. The heat transmission is based on 230 B.t.u. per hour per square foot of surface per degree difference in temperature between the steam and the circulating water. With steam at 212 deg. and water at 185 deg., this difference would be 27 degrees.



FIGS. 3 AND 4. LIVE STEAM AND EXHAUST HEATER DESIGN IN DETAIL
Fig. 3—Live-steam heaters. Fig. 4—Allan duplex or combination heater

It is self-evident that what is known as the closed type of heater must be used in this work, or in other words, a heater where the steam does not come in direct contact with the circulating water. If the open type commonly employed for heating boiler-feed water were used, the circuit would be broken and the circulating pump would have to lift against the static head to the highest point of the system, as well as the friction head, to say nothing of other complications due to siphonage.

Any good tubular heater may be used for this work, the problem being the same as in ordinary condenser practice, except that the circulating water is higher in temperature and additional tube surface must accordingly be provided to insure a given amount of heat transmission.

Generally speaking, the various standard forms of tubular heaters are more expensive than the conditions call for, as they are almost invariably constructed with brass or copper tubes. The same water is used over and over, and fresh water with fresh impurities having affinity for iron is not introduced in the system in sufficient volume to make brass or copper tubing necessary. On the other hand, there is no objection to copper or brass tubing excepting the first cost, and some engineers prefer this type. The great majority of these plants are provided with heaters in which ordinary 2-in. lap-welded boiler tubing is used. Fig. 2 shows five sizes of exhaust-steam heaters, which will cover all ordinary conditions in actual practice. The cut is self-explanatory, showing all details, including tube spacing, thickness of metal, etc. Accompanying the cut is a table giving all dimensions, number of tubes, heating surface, heat transmission, size of connections, weight, etc. The heat transmission is based on 230 B.t.u. per hour per square foot of surface per degree difference in temperature between the steam and the circulating water. With steam at 212 deg. and water at 185 deg., this difference would be 27 degrees.

The considerations governing the selection of the proper type of live-steam or auxiliary heater are the same except that it must be built to stand boiler pressure and will naturally be smaller, as the temperature difference between the steam and the circulating water is greater, and therefore the heat transmission per square foot will be greater and the tube surface required much smaller.

Assuming steam at 60 lb. pressure, the temperature difference above the circulating water at 185 deg. would be 122 deg., or about 4½ times greater than with exhaust steam. Thus 4½ times more heating surface

would be required in the exhaust heaters to give the same gross heat transmission.

Fig. 3 shows in detail five sizes of live-steam heaters that will give approximately the same heat transmission as the exhaust-steam heaters correspondingly numbered. Data for this type of heater are given in the accompanying table.

TABLE III. DIMENSIONS, HEATING SURFACE, WEIGHT, ETC. (SEE FIG. 3)

No.	Dimensions in Inches A	B	C	D	E	No. of 2-In. Tubes	Heating Surface Length B Ft.	In.	Sq.Ft.	B.T.U. per Hr. Stm. 60 Lb. Gage Water 185 Deg. 122x230xSq.Ft.	Average Size Connections Steam Inlet	Steam Drip	Water Both	Rel.	Weight in 2,000-Lb. Tons Empty	Full	Lb. per Sq.Ft.	Size Pipe Legs Ex. Heav.
1	40½	54	56	10	15	139	4	6	313	8,782,780	4½	2½	7	1	2.4	3.1	15.4	4
2	45	60	62	10	15	181	5	0	453	12,711,180	5	2½	8	1	3.0	3.9	13.2	4
3	49½	66	68	10	15	223	5	6	614	17,228,840	6	3	9	1¼	3.6	4.9	11.6	4
4	54	72	74	10	15	265	6	0	795	22,307,700	7	3½	10	1½	4.5	6.3	11.2	5
5	58½	78	80	10	15	313	6	6	1,018	28,565,080	8	4	12	1½	5.3	7.7	10.4	5

As will be evident in the illustrations, the construction of these heaters differs somewhat from the low-pressure type. There are no removable heads, which obviates the danger of a head blowing off. The lower half of the shell is vacant, leaving a space for removing tubes, and access to the inside of the shell is obtained through manholes.

Fig. 4 shows a combination or duplex heater, the invention of the writer, having separate live- and exhaust-steam compartments and a common water chamber. This heater is also shown in five sizes, each having approximately the same capacity as both the live- and exhaust-steam heaters of corresponding numbers. The advantage of this type is saving in first cost in foundations, covering and connections, and saving in steam necessary to warm up a cold heater when changing from the use of exhaust to live steam.

In connection with the operation of these heaters, the question that most naturally presents itself is why an auxiliary heater designed for the use of live steam under boiler pressure is necessary at all. Why not use one heater only of the low-pressure type and when live steam is necessary, admit it through a pressure-reducing valve? The answer is that it is cheaper when interest on investment and maintenance are considered to use live steam under boiler pressure during cold snaps, which are usually not of long duration, than it is to put in enough radiation to heat with exhaust steam under all conditions. Radiation can then be installed on a low-pressure steam system basis, and the temperature of the circulating water raised by means of the auxiliary heater to 212 deg. or even slightly above on the few excessively cold days that occur during the season.

All these heaters are in every respect an ordinary boilermaker's job and can be built in any good boiler shop at about the same cost per pound as an ordinary horizontal boiler without grates and other trimmings.

TABLE IV. DIMENSIONS, HEATING SURFACE, CONNECTIONS, WEIGHT, ETC. (SEE FIG. 4)

No.	Dimensions in Inches A	B	C	D	E	F	G	H	I	Heating Surface Live Steam No. 2 In. Tubes	Lgh. F Ft.	In.	Sq.Ft.	Ex. Steam No. 2 In. Tubes	Lgh. E Ft.	In.	Sq.Ft.	B.T.U. per Hr. Stm. 1 Lb. Gage Water 185 27x230xSq.Ft.	Average Size Connections Subject to Variation to Suit Conditions Live Steam Inlet	Live Steam Drip	Exhaust Inlet	Exhaust Vent	Exhaust Drip	Exhaust Water Both	Rel.	Weight 2,000-Lb. Tons Empty	Full	Lb. per Sq.Ft.	Size Pipe Legs Ex. Heav.
1	66	33	209	27½	154	88	37	12	18	85	7	4	312	264	12	10	1,694	10,519,740	4½	2½	12	6	3	7	1	9.49	15.26	9.5	5
2	72	36	228	30	168	96	40	12	18	109	8	0	436	318	14	0	2,226	13,823,460	5	2½	14	7	3½	8	1	11.56	18.95	8.7	5
3	78	39	247	32½	182	104	43	12	18	127	8	8	550	384	15	2	2,912	18,083,520	6	3	16	8	4	9	1½	14.42	23.75	8.3	5
4	84	42	266	35	196	112	46	12	18	163	9	4	760	468	16	4	3,822	23,734,620	7	3½	18	9	4½	10	1¾	17.79	29.64	7.8	6
5	90	45	285	37½	210	120	49	12	18	187	10	0	935	534	17	6	4,673	29,019,330	8	4	20	10	5	12	1¾	21.17	35.87	7.6	6

The Electrical Study Course—Circular Mil Formula

In determining the size of conductors, the circular-mil formula ranks in importance with the wire table. For this reason considerable space in this lesson is given to consideration of this formula, as well as working out the problems given in the previous lesson.

THE first problem in the last lesson was: "The resistance of 650 ft. of copper, 83,690 cir.mils in cross-section is 0.0818 ohm. Find the resistance of 1500 ft. of round copper 707 mils in diameter."

If both conductors had the same cross-sectional area, the resistance of the 1500-ft. conductor would be found by the proportion 650 : 1500 :: 0.0818 : x, from which $x = \frac{1500 \times 0.0818}{650} = 0.189$ ohm. The diameter of the 1500-ft. conductor is 707 mils; then the cross-sectional area in circular mils will be diameter in mils squared, or $707 \times 707 = 499{,}849$. Since the cross-sectional area of the 1500-ft. conductor has been increased over that of the 650-ft. conductor, the resistance of the former for a given length will be decreased and will be found by the proportion 499,849 : 83,690 :: 0.189 : x, from which $x = \frac{83{,}690 \times 0.189}{499{,}849} = 0.0316$ ohm. By referring to the wire table it will be found that the given resistance in the problem was approximately that for 650 ft. of No. 1 conductor, the resistance of which is 0.1258 ohm per 1000 ft. The conductor of which we calculated the resistance is approximately 500,000 cir.mils in cross-section. The resistance of 1000 ft. of 500,000-cir.mil conductor as found from the table is 0.021 ohm. Then the resistance of 1500 ft. would be $0.0210 \times 1.5 = 0.0315$ ohm, against 0.0316 as calculated from the resistance of the 650-ft. conductor.

The second problem was: "Find the size of conductor in circular mils required to transmit 235 amperes 875 ft., allowing a drop of 4.5 per cent. in the line. The

voltage E at the source is 575. Also find the resistance of the line, resistance per 1000 ft. of conductor, the voltage at the load and the diameter of the conductor in mils."

The volts drop $E_d = \frac{E \times \textit{per cent. drop}}{100} = \frac{575 \times 4.5}{100}$ = 25.875 volts. The voltage at the load $E_a = E - E_d = 575 - 25.875 = 249.125$, and the resistance of the two conductors is $R = \frac{E_d}{I} = \frac{25.875}{235} = 0.11$ ohm. The total length of conductor in the problem is $L = 875 \times 2 = 1750$ ft. Then the resistance per 1000 ft. $= \frac{R \times 1000}{L} = \frac{0.11 \times 1000}{1750} = 0.0629$ ohm. Referring to the wire table, it is found that the nearest size conductor to one having a resistance of 0.0629 ohm per 1000 ft. is a No. 000, which has a resistance of 0.0625 ohm per 1000 ft. The carrying capacities given in the table for a No. 000 wire is 175 amperes for rubber cover and 275 amperes for other insulation. If we assume that the conductors are to be used for inside work, then a rubber-covered conductor is required and we cannot use the size calculated, but must use a larger wire to conform with the National Board of Fire Underwriters' regulations. The size of a rubber-covered conductor that will meet these requirements is 250,000 cir.mils in cross-sectional area. This conductor is rated for 240 amperes and has a resistance of 0.042 ohm per 1000 ft. The resistance of 1750 ft. will be $1750 \times 0.042 \div 1000 = 0.0735$ ohm, and the volts drop when 235 amperes is flowing through the circuit is $E_d = RI = 0.0735 \times 235 = 17.27$, against 25.875 volts that was allowed. With the larger-sized conductor, the voltage will be maintained more nearly constant at the load with variations in the value of the current.

The size of conductor to transmit 235 amperes 875 ft. with 25.875 volts drop in the line may also be found by the formula given in the last lesson,

$$Cir.mils = \frac{21.4DI}{E_d} = \frac{21.4 \times 875 \times 235}{25.875} = 170{,}000$$

which checks up very closely with the cross-sectional area of a No. 000 conductor as given in the table. The diameter of a round conductor in mils is equal to the square root of the cross-sectional area in circular mils, or, in our problem, diameter in mils $= \sqrt{170{,}000} = 412$.

Derivation of Circular-Mil Formula

The formula for finding circular-mil area of a conductor to transmit a given current is based on the resistance of 1 circular-mil-foot of copper. A circular-mil-foot is a wire 1 ft. long and 1 cir. mil in cross-section, or in other words a round wire 1 ft. long by one thousandth of an inch (0.001 in.) diameter. The resistance of 1 cir.mil-ft. of copper is given different values for different temperatures, varying from 10.5 to 11 ohms, 10.7 ohms being a good average value. The foregoing statement means that if a round section 1 ft. long and 0.001 in. diameter is taken from any copper wire, it will have a resistance of 10.7 ohms at a temperature of about 70 deg. F.

If we take a 1-ft. section of a conductor and consider this made up of a number of wires in parallel, each element 1 cir.mil in cross-sectional area, each one of these little wires will have a resistance of 10.7 ohms, and if the cross-sectional area of the conductor is equivalent to 100 cir.mils, the resistance of the 1-ft. section will be $10.7 \div 100 = 0.107$ ohm. Looking at this in another way, if the conductor is 100 cir.mils in cross-section, we have a condition similar to that if the wire was made up of 100 wires each 1 cir.mil in cross-section. In this case the same law will apply as when connecting equal resistances in parallel; that is, the joint resistance of the group would equal the value of one resistance divided by the number connected in parallel. In our problem we considered that the 1-ft. section of conductor was made up of 100 wires 0.001 in. in diameter and that each wire had a resistance of 10.7 ohms. Since there are 100 in parallel, the joint resistance will be $\frac{10.7}{100}$, or 0.107 ohm. If the cross-sectional area of the 1-ft. section was equivalent to 1000 cir.mils, then the resistance of the piece would be $10.7 \div 1000 = 0.0107$ ohm.

Resistance per Foot of Conductor

From the foregoing it is evident that the resistance of a 1-ft. section of any copper conductor is equal to 10.7 divided by the circular-mil cross-section. Take, for example, a No. 8 wire. Its resistance is 0.641 ohm per 1000 ft. This is equivalent to 0.000641 ohm per foot. The sectional area of a No. 8 wire is 16,510; then the resistance per foot equals $10.7 \div$ cir.mils $= 10.7 \div 16{,}510 = 0.000648$ ohm, against 0.00641 ohm given in the foregoing. As another example, take a 300,000-cir.mil conductor, the resistance of which is 0.035 ohm per 1000 ft., or 0.000035 ohm per foot. From the method described, the resistance per foot $= 10.7 \div$ cir.mils $= 10.7 \div 300{,}000 = 0.0000356$ ohm, which checks up fairly close to that given in the wire table.

Since we have a method for determining the resistance per foot of any copper conductor, all that is necessary is to multiply the result thus obtained by the length of the conductor in feet to find the total resistance. If we denote the length of the conductor by L, then the resistance of the conductor is $R = \frac{10.7L}{cir.mils}$.

To illustrate, the resistance of 1750 ft. of No. 2 conductor is 0.276 ohm, as calculated from the resistance per 1000 ft. given in the wire table, and the cross-sectional area is 66,370 cir.mils. Calculating the resistance from the foregoing formula.

$$R = \frac{10.7L}{cir.mils} = \frac{10.7 \times 1750}{66{,}370} = 0.282\ ohm$$

against 0.276 ohm as calculated from the data given in the wire table.

Since circular mils is one of the elements in the formula for finding the resistance R, the expression may be made to read cir.mils $= \frac{10.7L}{R}$ for finding the circular mils. The lengths of circuits are usually expressed in the distance one way, and not in the total length of wire in them, and the value of the volts drop and current transmitted are more readily at hand than the resistance of the circuit. Therefore, we will express the length L of the conductor in the two-wire circuits by $2D$, where D equals the distance one way, and the resistance of the conductors is as already shown to be, $R = \frac{E_d}{I}$. By sub-

stituting these equivalents for L and R in the formula, the expression becomes

$$Cir.mils = \frac{10.7 \times 2D}{\frac{E_d}{I}} = \frac{21.4DI}{E_d}$$

which is the formula we use to find the size of conductors in problem 2. The formula may be transposed to read

$$E_d = \frac{21.4DI}{cir.mils}$$

for finding the volts drop in a given circuit, or to read

$$I = \frac{cir.mils \times E_d}{21.4D}$$

for finding the current that may be transmitted through a given circuit with a given allowable voltage drop.

1. In a circuit 750 ft. long, one way, in which 350,000-cir.mil conductors are used, if the voltage at the load is 230 when 175 amperes is being transmitted, find the volts drop in the line, the volts at the source of power, the resistance of the conductor, the total watts supplied to the line, the watt loss in the line and the watts supplied to the load.

The following problem was submitted by a reader and, since it is similar to some of those given in previous lessons, it is given here for practice.

2. A set of 48 vehicle battery cells is to be charged by direct connection to a 110-volt line. At starting the charge, the voltage of each cell is 1.9 and when nearly charged, 2.28 volts. If the resistance of the cell is considered constant at 0.001 ohm throughout the charge, what will be the charging current at the beginning of the charge, and at the end of charge when the voltage has reached full value; also make a diagram to show how they are connected.

Testing Boiler-Feed Water

BY G. E. MILES

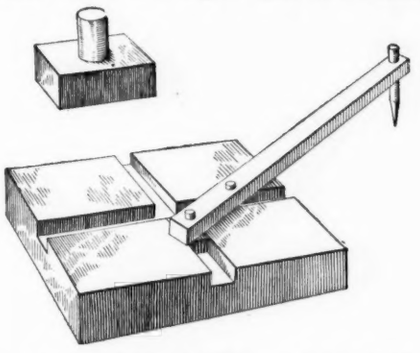
Boiler-water treatments, like treatments for human ailments, cannot be expected to produce satisfactory results unless properly applied. The usual method of treating feed water by administering a certain quantity of the material according to the amount of water evaporated, falls down because very few engineers have any idea how much water is being evaporated, and the quality of the water often varies from day to day, and the amount of water lost by leakage and by blowing down the boiler is an uncertain quantity. It is safe to say, at the end of a week's run, no estimate can be made as to the strength of compound in a boiler that has received a definite quantity each day.

In a case where sodium carbonate was used, the scale yielded readily to the treatment when just the right quantity was used, but on several occasions the soda in the boiler was permitted to get too strong and foaming occurred. After a few experiences with foaming, the engineers became too cautious and failed to use enough soda to remove or prevent the scale. Thus the importance of some test to enable the engineer to know the concentration of the soda in the boiler became apparent and the following titration test was adopted: A solution was made consisting of 13.3 c.c. of sulphuric acid in a total of 1000 c.c. of acid and distilled water, an indicator was made with phenolphthalein dissolved in alcohol, 50 c.c of water from the water column of the boiler was taken as a test sample, a few drops of the indicator added, then sufficient acid solution to just cause the pink color to disappear. The number of cubic centimeters of the acid solution required was a measure of the strength of the soda in the water. Good results were obtained when it took 5 c.c. of the acid solution to neutralize the soda. This corresponded to about 5 per cent. of soda in the water. One of the engineers was required to make the test every day and report the result and add enough soda to the feed water to keep the strength right, after which there was no trouble from foaming or scale. The same test can be applied to any boiler compound that consists largely of soda ash, but the necessary strength to be maintained must be ascertained for the particular compound and feed water used.

An engineer and boiler inspector of wide experience recently told the writer that his observation had convinced him that there was no feature of the steam plant so much neglected and so little understood as the feed-water treatment and the cleaning and care of boilers. In one plant where a certain water and compound were used, clean boilers would be found, but in another plant where water from the same source and the same compound were being used, the boilers were very dirty. In the second case the engineer complained and found fault with the compound, but in the majority of cases the proper concentration was not maintained in the boilers.

A Handy Ellipsograph

The illustration, taken from the *Practical Engineer* (London), shows a practical and easily made device for drawing an ellipse. It consists of two channels, at right angles to each other across the face of a board, any suitable width and depth, and two sliding blocks



DEVICE FOR DRAWING AN ELLIPSE

made to fit. These blocks may be made of hardwood and are preferably longer in the direction of their travel than the width of the slot. It is obvious that the distance from the pencil or tracing point to the pivot of the farthest block is the long radius and from the pencil to the pivot of the other block is the short radius of the ellipse.

In 33 years the production of iron in the United States has increased 337 per cent.; petroleum, 391 per cent.; copper, 1200 per cent.; cement, 2087 per cent.; lead, 125 per cent., and zinc, 638 per cent. During the same period the coal production has more than trebled.

The Martindale Efficiency Meter

In order to know how well his plant is doing, an engineer must take account of two or more factors. If he burns more coal one day than another, it does not necessarily mean that the plant is running less efficiently. It may have used more steam, and the evaporation per pound of coal may have been even better than when less coal was burned.

This ratio of output to input is the efficiency, and some such ratio, be it pounds of steam per pound of coal, pounds of coal per kilowatt-hour or what not, is what the engineer looks to as the index of the performance of his plant.

There have long been in use recording gages for simple quantities and rates, such as pressure, kilowatts, etc., but their indications must be combined with the indications of other instruments in order to get average or momentary results which mean anything. This means averaging the diagrams either with a planimeter or by a multiplicity of measurements, and dividing output by input to get the average ratio, or the measurement of both input and output at various points, individual divisions of these simultaneous quantities and the tedious plotting of a combined diagram if it is wished to know how the efficiency has varied during the day.

What is needed is a recording meter that will draw a record of the ratio of two quantities, such as pounds of water evaporated per pound of coal, pounds of steam per kilowatt-hour, or pounds of yarn per horespower. The efficiency meter invented and developed by the Martindale Co., of Bay City, Mich., is designed to do just this. In the chart shown in Fig. 1, for example, the input curve is a measure of the coal burned, the output curve of the water evaporated, and the outer or efficiency curve of the water evaporated per pound of coal.

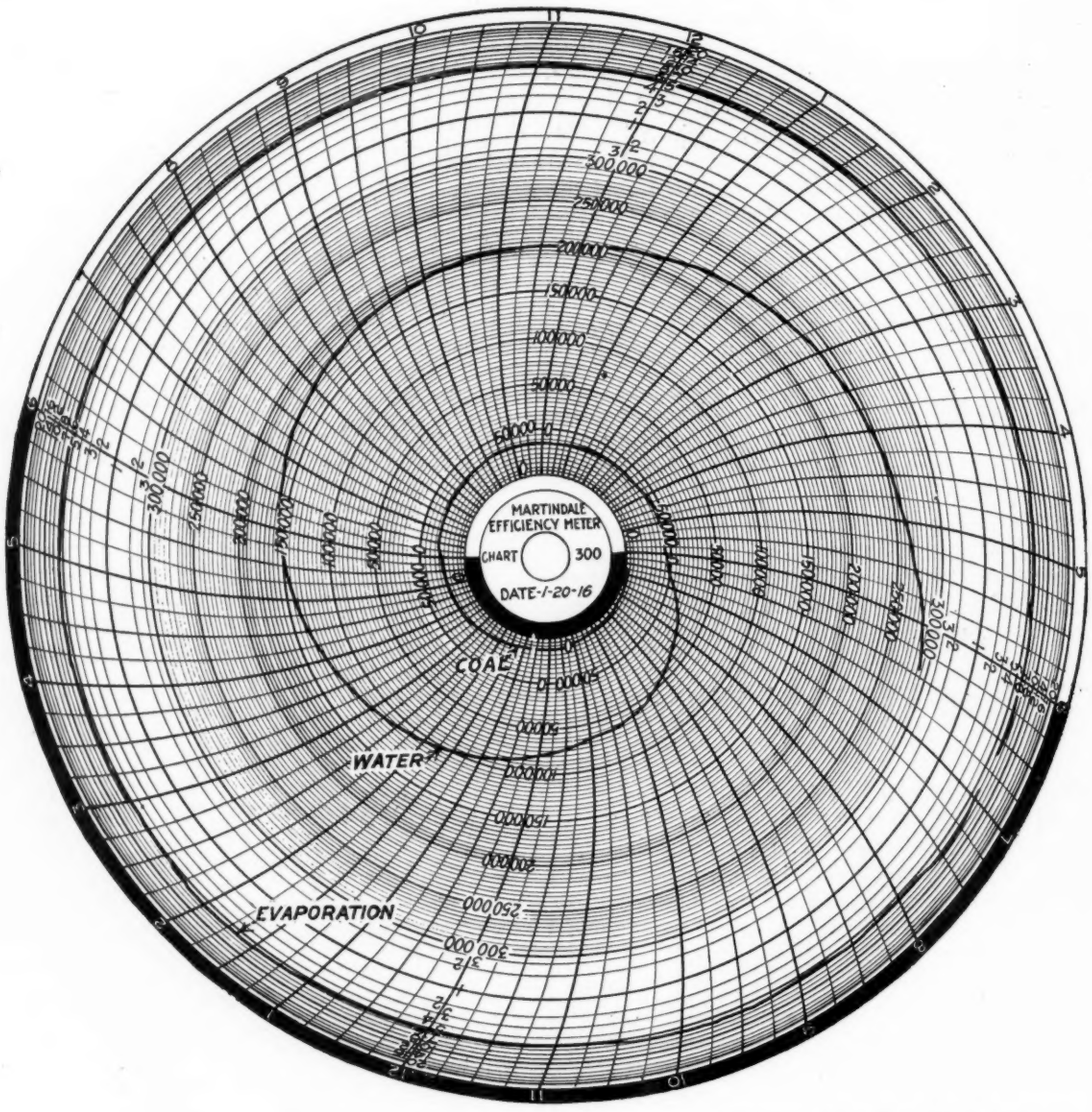


FIG. 1. CHART SHOWING AMOUNTS OF COAL BURNED, WATER EVAPORATED AND WATER EVAPORATED PER POUND OF COAL

The eight dials in the instrument shown in Fig. 2 are the indexes of the receiving apparatus, four for input and four for output. One of these might be attached to the plunger mechanism of a mechanical

stoker, another to the indicator of a V-notch meter by means of a specially designed integrator, or meter reader. The pointer on the coal dial is set to the position indicating the number of pounds of coal delivered by the plunger per stroke and that upon the water dial to the position indicating the number of pounds of water calculated as a unit from the water meter by the meter reader. Every time the plunger works, it makes an electric contact and energizes an escapement mechanism which adds the quantity of coal that has been delivered to the fire to the record of coal consumed. Similarly, electrical impulses add to the record the amount of water

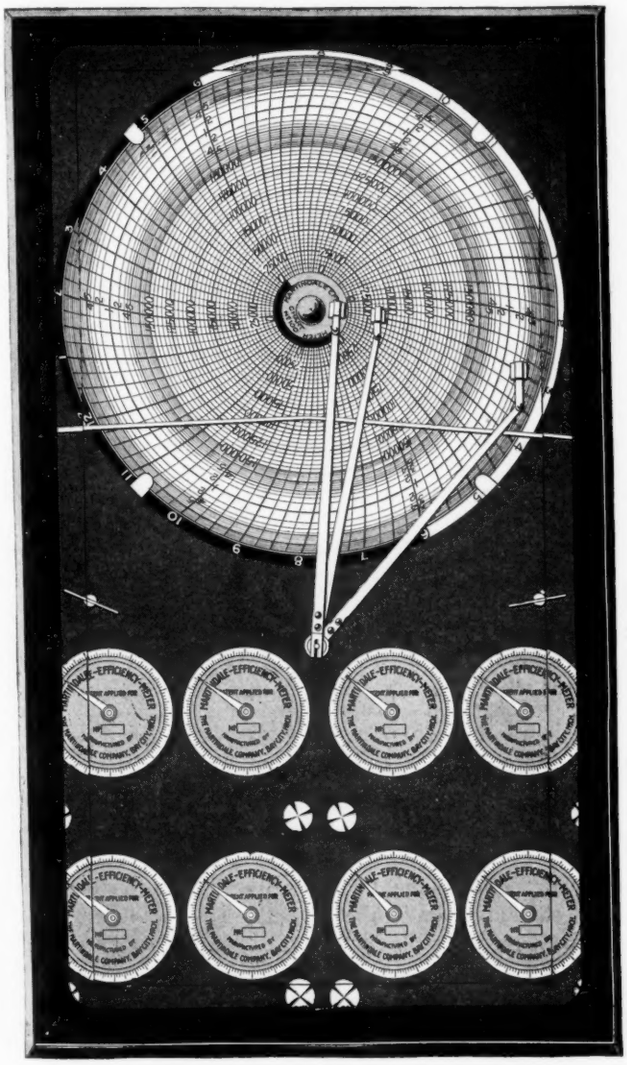


FIG. 2. THE MARTINDALE EFFICIENCY METER

passed through the meter, while, by an ingenious arrangement of cams and dividing arms, the third or outside pen is made to record the ratio of these two quantities and to draw a continuous chart of the water evaporated per pound of coal. In the chart shown, the coal record begins with zero at 6:30 a.m., and in twenty-four hours has increased to nearly 50,000 lb., which is the limit of the scale. The zero of the water record is at the 50,000-lb. line of the coal record, and the diagram reaches 255,000 lb. in these twenty-four hours. The efficiency diagram lies outside of the water diagram. Its divisions are logarithmic, quite small between 8 and 12, where the pen should stand most of the time and much larger at 1 and 2 where, for this particular record at any rate, the pen would seldom be. It would seem that one more cam might be used to advantage in making this principal scale uniform. The divisions are, however, much plainer upon the original 12-in. chart than upon this reproduction of it. There is no zero to this scale. When the output becomes equal to the input the ratio—that is, the value of output ÷ input—becomes unity and the pen would be traveling on the line 1. As the output grows relatively smaller, the pen drops below this line and the divisions are the reciprocals of the similarly numbered lines above. If the instrument were used to record pounds of water evaporated per pound of coal, the pen should travel, say, on the division marked 8 above the unit line, but if it were used to indicate kilowatt-hours per pound of coal it would travel, say, on the line numbered 3 below unity, signifying 3 lb. of coal per kilowatt-hour or $\frac{1}{3}$ of a kilowatt-hour per pound of coal.

Since the meter is electrically operated, it permits the divorcing of the measuring mechanism from the recording apparatus. The accuracy of any measuring instrument depends largely upon its location. The usefulness of the recording device depends upon its accessibility. It seldom occurs that the position permitting the greatest accuracy coincides with the position that is the most accessible. The utility of both devices, therefore, is promoted by the separation. With the measuring apparatus in the most desirable location, the recording instrument may be placed opposite an executive's desk or anywhere desired. It is practicable to install individual instruments accessible to the operatives and a master instrument compiling all their totals near the proper executive.

The mechanical integrator above mentioned used to connect to the V-notch meter may be similarly attached to any steam flow meter, or other rate indicating instrument. It is unique in that it is the first device to produce a continuous record of amounts from rate indications. By means of this integrator on rate indicating instruments and simple electrical contacts on instruments indicating amounts, the Martindale efficiency meter may be connected to any automatic quantity measuring device.

With efficiency records similar to the above, kept daily, a falling off in the overall efficiency can be readily noted without further calculations or additional data. The engineer is thus furnished with a prompt indicator of efficiency and is therefore enabled to direct his attention to its probable cause. Losses may then be stopped promptly. With the cause of inefficiency remedied, this record again serves him because the normal record checks the fact that he has properly corrected the source of his losses. Plant efficiency and capacity, therefore operating costs, may be checked in this manner as readily as the steam pressure, and is available to all parties interested.

Driving a Diesel engine with gas made from peat is one of the developments of the coal and oil shortage in Denmark, says *Commerce Reports*. A large engine shop in Copenhagen announces this new adaptation

Perpetual-Motion Discussion

It seems from letters being received that there are still some who do not see the futility of expecting to get "something for nothing" mechanically by means of perpetual motion, or, as some of the devotees choose to term their devices, "power-increasing machines." In the issue of Jan. 30, page 148, two such devices were gone over and, as we supposed, disposed of, but typical persistence prevails; hence the following discussion and illustrations intended to disprove the assertion that the buoyant action of a fluid on a body is greater than the force necessary to enter or submerge the body into the fluid.

In Fig. 1 the pressure on the top of the floating cube *A* is that of the weight of a column of water of the height *ab* and of a cross-section equal to the area of the top of the cube. The pressure per unit of area on the plane *cd* is that due to the depth *ef*. This pressure acts equally in all directions, and pressing upward upon the bottom of the cube tends to lift it with a force equivalent to the weight of a column of water of the height *ef* and of a cross-section equal to the bottom of the cube. The difference between the upwardly and downwardly acting forces exerted by the liquid then is equal to the difference between the weights of two columns of the lengths *ef* and *ab*, each having a cross-section equal to that of the cube; and the difference between these weights will obviously be equal to the weight of a volume of water equal to the volume of the cube. This will work out the same way applied to a sphere or any other shape, regular or irregular. The buoyant effect is then equal to the weight of the liquid displaced by the floating body.

The *net* upward pull upon the cord of the body *A* in Fig. 2, is equal to the weight of the liquid displaced by that body (that is, to the weight of a volume of the liquid equal to the volume of the floating body) less the weight of the body itself. If the weight of the float is balanced by another float, as in the proposed machine referred to, the net upward effort will be the buoyant effect on the float, and equal to the weight of a volume of the liquid equal to the volume of the float. The work done is the product of the force and the distance through which it is exerted. In rising from the solid to the dotted position in Fig. 3, the float will do an amount of work proportional to the product of its buoyant effort (that is, the weight of an equal volume of the liquid) and the distance *ab*, which distance is the change in the depth of submergence of the center of gravity of the submerged volume.

In Fig. 4 the center of gravity of the submerged mass of the left-hand float is at *a;* of the middle float, at *b*. There is no submergence in the case of the right-hand float, but the center of gravity of the last bit of submergence that there was, was at *c*, so that in emerging from the position *a* to the position *c* the center of gravity of the submerged mass has moved only one-half as far as the center of the float, or from *d* to *c*. The work done, then, by the float in rising from the lower to the upper position in Fig. 5, is the product of the weight of an equal volume of the liquid into the distance *ab;* that is, into the total vertical movement of the float less the radius of the float; or, in the case of an irregular-shaped mass, less the depth of immersion of the center of gravity at the instant that the mass begins to emerge from the liquid; and it would take the same amount of work to push the float down through the liquid to its position at the bottom of the tube. This ought to be obvious. It takes as much work to raise a weight as the weight will do in falling; conversely, it takes as much work to sink a float as the float will do in rising. It will take just as much work to get the float into the immersed position, however it is done, even if it comes up through the bottom of the column. The change in immersion of center of gravity is what determines the work involved, and the path or process followed (friction neglected) makes no difference.

When the cube in Fig. 6 starts upward into the suspended body of liquid, its entry is opposed by the weight of the column *A*. The increment of movement which completes its entry is opposed by the column *B*, shorter by the height of the cube; the pressure per unit of area is initially that due to the depth *d*, finally that due to *d—h* (*h* being the height of the cube). Since the diminution of pressure is uniform, the depth to which the average pressure is proportional is found by adding the initial and final pressures and dividing by 2; thus,

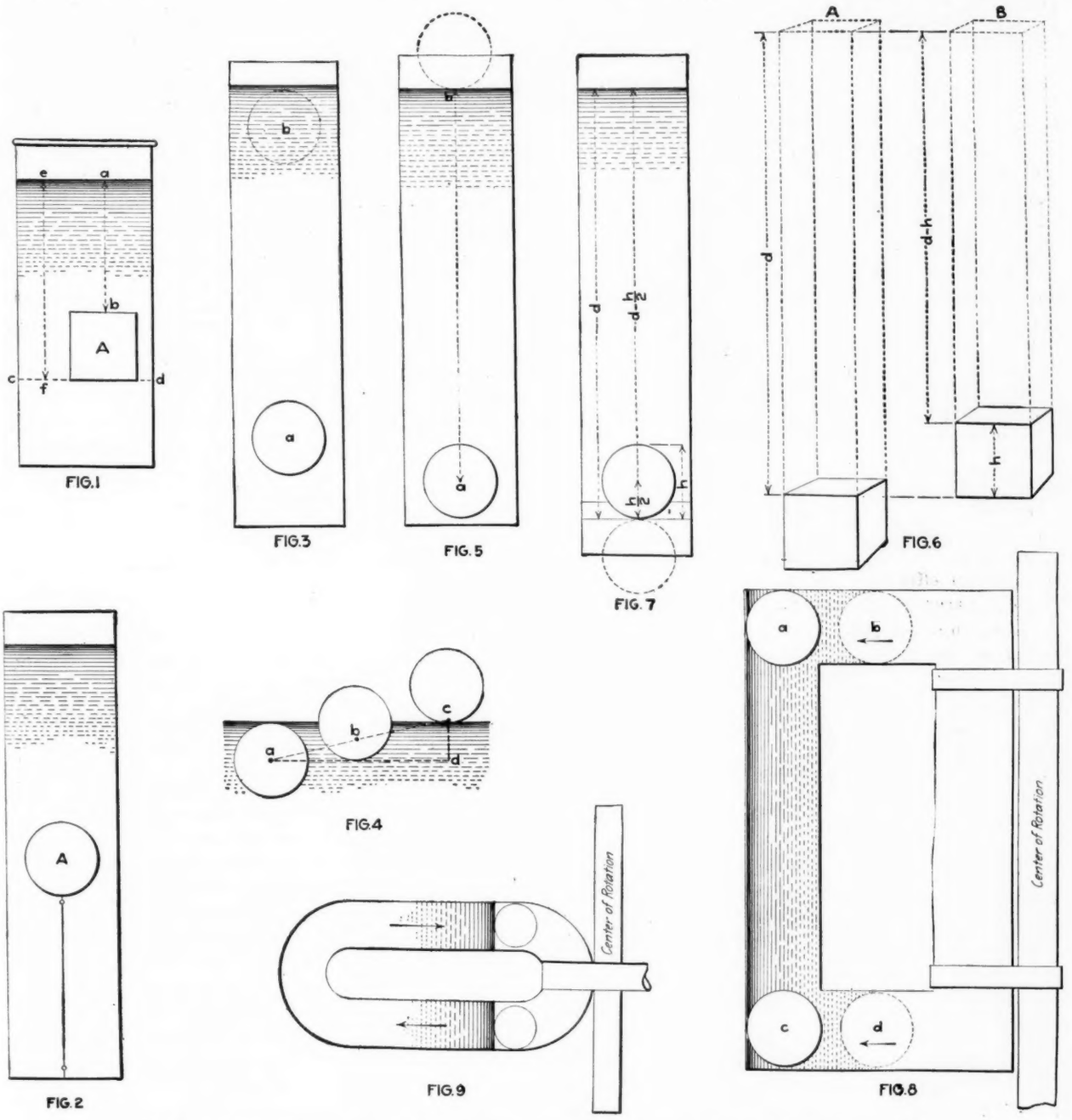
$$\frac{d + d - h}{2} = \frac{2d - h}{2} = d - \frac{h}{2}$$

If this average pressure per unit of area is multiplied by the cross-section of the cube (= the area of the top) the total average resistance to entry is obtained. Calling this cross-section *s*, then the average resistance overcome $= s\left(d - \frac{h}{2}\right)$ and the distance through which this resistance is overcome is the height *h* of the cube. The work done is the product of the average resistance and the distance through which it is overcome, or work $= hs\left(d - \frac{h}{2}\right)$. But the product (*hs*) of the height and cross-section of the cube equals its volume, therefore work = volume $\times \left(d - \frac{h}{2}\right)$. This conforms to the law that the work done is equal to the product of the volume displaced and the average pressure against which the displacement takes place; and this holds true whatever the shape of the volume may be; the distance $\frac{h}{2}$ is the movement during immersion of the center of gravity of the submerged portion of the body, whether it be symmetrical or irregular in shape.

It has been found that the float in Fig. 5 will do work in rising from the lower to the dotted position equal to the product of its volume and the distance *ab*. Also that to get the float from the dotted to the solid position in Fig. 7, would require an amount of work equal to the product of its volume and the distance $d - \frac{h}{2}$. But the distance *ab* of Fig. 5 is the same as the distance $d - \frac{h}{2}$ of Fig. 7, and as the volume is the same in both cases, the product of the volume and the distance is the same; so that it would take

as much work to introduce the float into the column from the bottom against the pressure due to the height of the column as the float would do in rising through the column.

In like manner it may be shown that no advantage can be gained from the centrifugal force when the device is rapidly rotated. As a matter of fact, the distance *cd*, but when the ball was in the upper part of the column and had to go out, it would have to come through the distance *ab*, equal to *cd* and against the same centrifugal force. Centrifugal force always acts outward from the axis, and no advantage can be got from it any more than from the force of gravity, which always acts toward the center of the earth.



FIGS. 1 TO 9. BUOYANCY, LIKE GRAVITY, CANNOT PRODUCE POWER CONTINUOUSLY

surface of the mercury would take the same parabolic shape as a liquid assumes in a rotating vessel, as described on page 148, in the issue of Jan. 30. Suppose it were possible by such rotation to put the mercury into the position shown in Fig. 8, the force on the lower ball tending to force it into the mercury, or the amount of work required to be done by centrifugal force, would be the average of that force through the

Again, conceive the tube to be flexible so that in rotating it takes the shape shown in Fig. 9. It would take more than the ordinary perpetual-motion imagination to see the balls travel outward in the lower tube and in the opposite direction in the upper one.

There is another action involved in the ball as conceived in Fig. 8, in that the ball will act as a brake on the rotating tube as it passes outward from the

axis, due to the fact that the tube has to put kinetic energy into it in increasing its velocity of motion, whereas this kinetic energy is restored to the rotating body at the top as the swiftly moving ball passes in toward the less swiftly moving path nearer the center. Attempting to force the ball of lighter material into the mercury by centrifugal force is very much like trying to sink a cork into a pail of water by placing it on the surface and then whirling the pail on a string about one's head.

Emergency Auto Starter

By M. A. Walker

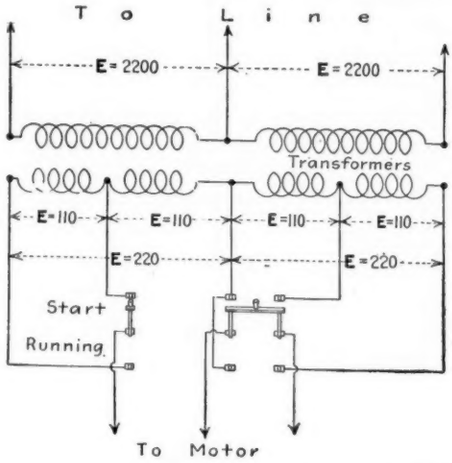
Fire had destroyed a pumphouse and with it the 50-hp. three-phase squirrel-cage induction motor used to drive the pump and the auto-starter. The pump maintained the water in a storage tank used for a small industrial plant. A spare 50-hp. motor was obtained from another plant, and an auto-starter was ordered from one of the large electrical manufacturers and was expected the next day. The distributing transformers previously used were three standard 2200- to 220-110-volt units, each of 15-kv.-a. capacity. These had all been damaged when the pole carrying them burned and fell to the ground.

Fortunately, two 20-kv.-a. transformers were available, which gave, when connected in "V" or open delta, about 58 per cent. of the capacity of three transformers of the same individual rating connected in delta, or a three-phase capacity of about 35 kv.-a. The motor required about 43 kv.-a. if fully loaded, but it was decided to take a chance on the motor being enough underloaded so that the transformers would be able to carry the load until larger ones in the form of three units connected in delta could be obtained.

After the motor and transformers had been installed, it was found that the compensator could not be procured without considerable delay. As water had to be obtained immediately, it was decided to eliminate the auto-starter for the time being. Since the transformer's secondary pressure was 110 and 220 volts, it was decided to try to use the half-pressure taps on their windings for starting. The regular starter consisted of a winding with taps brought out to give about 40, 60 and 80 per cent. line volts at the motor terminals, any one of which could be used. The minimum starting voltage for a particular condition should always be used, since the starting current is then kept at a minimum and the voltage fluctuaton will be less pronounced. The starting torque of an induction motor varies as the square of the voltage applied to its terminal; therefore, it is at once apparent that at half-voltage the torque will be reduced by four. This fact created considerable doubt as to whether the motor could develop sufficient torque at half-voltage to overcome the static friction of the motor and pump to bring it up to speed. Another element against the motor doing this was the fact that the transformers were connected in open delta.

In place of the auto-starter, a single-pole double-throw and a two-pole double-throw switch were installed. These two switches were mounted alongside each other so as to form a three-pole unit and the motor and transformers connected as shown in the figure. By throwing the switches to the up position, the motor will have impressed upon its terminals 110 volts at starting, and with the switches thrown down the motor is connected directly across the 220 volts, which in this case is full-line pressure. It might be well to mention that the starting voltage was connected to the upper studs with the idea in mind that should the starting switch ever fall down, the motor would start up none the worse except causing bad voltage fluctuations on the circuit, whereas, if left running in the starting position, the transformers might be overheated.

After checking the voltages, the switches were closed to the up position and the motor slowly came up to a speed somewhat less than full. Both switches were then thrown over together to the full-line voltage side; the motor then came up to full speed and everything was all right. After determining that all would work satisfactorily when both switches were operated together, the



CONNECTIONS FOR STARTING INDUCTION MOTOR FROM SERVICE TRANSFORMERS

effect of throwing over the double-pole switch alone and then the single-pole switch a few seconds afterwards was tried. The only result of this was to make the motor slow down a little and give a humming noise, which indicated that it was running single-phase.

The use of the half-voltage tap on the transformers and the two switches in place of another starter was but an emergency measure, being about the only thing that could be done under the circumstances. That the scheme was entirely satisfactory is best understood when it is stated that it has now been in use for over three years.

The Geneva Switzerland cantonal authorities are now requiring all persons who desire coal for immediate and winter use to submit a declaration giving the number of persons in an apartment or dwelling which is to be heated, the number in the family, the number of rooms in the apartment or dwelling, and the supply of coal on hand. All this information it is proposed to collate, and then issue orders allotting coal in proportion to the number in a family and the size of an apartment or dwelling. The number of cubic meters of gas that may be consumed by families is regulated on the same basis. These restrictions as to coal and gas will cause families to content themselves with much less than they have been accustomed to use.—*Commerce Reports.*

Editorials

Engineers and Engine Tenders; Salary and Wages

OUR editorial on "The Engineer and the Union" has brought out a number of communications, of which one is published on page 638. The author's gibes at the oil-can artist who tries to make a "profession" out of shoveling coal and shining brasswork are not without targets. The propensity to overrate the quality and importance of his service on the part of an occasional power-plant worker, however, is negligible as compared with the failure on the part of the public and the employer to recognize the really scientific, technical and executive qualifications of the man who successfully and efficiently directs the operation of a power plant.

A former president of the N. A. S. E. used to say that, as concerned the man in the power plant, practice without theory was worth two-and-a-half to three dollars a day; theory without practice was not worth a red cent, but theory and practice combined were worth from twenty-five hundred a year up.

It would be hard to define the precise point at which the engine tender becomes an engineer and his wages become salary. The man who performs only manual labor and whose responsibilities are confined to doing a job that somebody else has laid out for him can hardly aspire to professional recognition. On the other hand, the intelligent administration of a large power plant offers opportunity for the exercise of the best and most that a course in a technical school comprises, not only in physics, chemistry, electricity, thermodynamics and mechanics, but in accounting and the management of men; and to this technical knowledge must be added a practical facility won by years of intimate association with the apparatus under his charge. The combination is usually the result of the acquirement of the essential knowledge of the fundamentals by thinking, observing power-plant employees who get the study habit and apply their learning as they get it.

To this larger man the union does not appeal. The public impression of him is still cluttered up with his overalls; his employer is still prone to regard him as a "hand" rather than as a member of the executive staff; but he continues to hope for recognition and compensation commensurate with his attainments and responsibilities.

But there are those, as these letters show, to whom the union does appeal. One of the letters incloses a number of advertisements offering from six dollars a day to fifty dollars a week for steamfitters. Brick and tile layers, structural-iron workers and other members of organized trades get similar wages. Engineers in organized lines like the breweries get better pay than those not organized. Steamfitting is only one of the qualifications of an engineer, and he hires bricklayers and shows them what to do. When he sees these men getting more pay than he does for less work and responsibility, not because of any special skill that they possess but because they belong to the union, is it to be wondered at that he sees in that direction a possible betterment of his condition?

We do not believe that the union idea is economically sound. All the necessities of life are simply materialized labor. If labor exacts greater wages the laborer will, in the final analysis, pay back all the increase and more in the greater price of these necessities consequent not only upon his greater wage, but upon the imposition by capital and industry of greater interest and profits on the large amounts involved. But if some organize successfully, those who do not organize suffer from the success of the others without any increase in their own means to meet the greater cost.

The average employer intends to be just. The low rate of pay of engineers is the result of the persistence of outgrown conditions rather than of deliberate intention. Would it not be well to beat the union to it by making it unnecessary for your engineer to join in a movement for collective demand?

Industrial Research

THE changing economic conditions in this country brought about by the war have made it necessary that a tremendous amount of research work be carried on, not only in the industries that were well established when the conflict broke out, but also in the development of new industries to supply the necessities that we had been accustomed to obtain in whole or in part from Europe. That this country has risen to the emergency is evidenced by the vast amount of research that is being carried on at the present time. Never before were so many interested in research work and its promotion. In a paper, "Industrial Research and Its Relation to University and Governmental Research," presented by C. E. Skinner at the three hundred and thirty-third meeting of the American Institute of Electrical Engineers in Philadelphia, October 8, 1917, the author, in referring to the increased activity in industrial research, says:

"Many industrial corporations which were not provided with research facilities heretofore are making such provision, and many of those having such facilities are making considerable additions, both for increased amounts and for an increased variety of research. Research departments and scholarships are being provided for in universities and colleges. Commercial-research laboratories are being promoted to serve groups of industries where individually they cannot economically provide their own facilities. Scientific and engineering organizations are appointing research committees, and research organizations, such as the National Research Council, are being formed. We have research provided for by private gifts and by governmental grants. The Federal Government is constantly

increasing its research facilities in its various departments, such as the Bureau of Standards, the Bureau of Mines, the Forest Products Laboratory, the Agricultural Experiment Stations, etc. This movement is not only national, it is international. Commissions from abroad have studied research conditions in the United States, and the United States has sent men to our allies to study their progress in research in connection with the war."

Further evidence of the forces at work to promote industrial research was the two hundred and twenty-seven members and guests who attended the previously mentioned meeting to consider this subject. Probably never before in this country was there a greater interest displayed in an engineering subject. This is all the more remarkable since almost every engineer at this time is overwhelmed by the duties devolved upon him owing to the stress of the present intensified industrial conditions.

There can be but one conclusion as to this increasing activity in industrial research upon which all industrial development depends. If such organizations are a benefit in times of national stress and need, surely they can be of value in times of peace and must lead to America making her greatest advances as an industrial people.

Saving Coal at the Lamp

IS IT not about time to realize that through the better care of lighting units and a more personal interest on the part of the steam engineer in curtailing wasteful burning of lamps, a good many pounds of coal can be saved during the coming winter? It is amazing that with all that has been published in the daily press of late regarding the importance of economy, so much carelessness in the use of light should still be in evidence. No one is asked to reduce the standard of illumination to a point where injury to eyesight results or even threatens; but there is certainly room for patriotic service on the part of a good many persons in taking positive steps toward conserving fuel through a reduction in the amount of needless illumination as at present displayed.

In a good many industrial plants the engineer does not feel that it is his business to attempt to curtail the use of light in departments other than his own. This is a natural feeling, but it is time to take active measures against the waste of fuel, if it ever was. What better course could be followed than for the chief and his superior to hold a conference leading to a formal recognition by the entire personnel of the establishment and to charge the engineer with the duty of tactfully but firmly preventing waste in the use of electricity? Certainly, no one could possibly find any reasonable grounds for objection to the closer control and probable reduction of corridor illumination in many cases; and it would be a good thing for the engineer to make inspection tours in other parts of a plant outside his boiler and engine room, to which in so many cases he is strictly confined unless an outside interruption of service occurs.

The gas-filled tungsten lamp has reached a stage of development where it now can be used to advantage in many kinds of indoor service formerly considered the sphere of the vacuum unit alone. Higher intensity at the filament can be readily enough reduced, with respect to human vision, by the provision of semi-opaque or moderately translucent fixtures, and there are many plants where a modest outlay for such equipment would save considerable coal by the end of the winter.

It is not all a question of coal cost and the money with which to meet it; it is actually important to do everything in reason to save coal itself. Multiplied savings of ounces make up pounds, tons and finally carloads, sorely needed for the transportation of other war material than fuel as well as for the carriage of fuel itself to the seaboard for shipment to our allies. Nations are engaged in modern warfare, not merely armies, and the sooner we realize that individual patriotic reductions in waste contribute to the ultimate success of our common country in the mighty undertaking in which it is engaged and will carry to completion, the better. Let the engineer's authority as an efficiency man extend to illumination and perhaps even to supervision of the maintenance of illuminants, on behalf of the great and subdivided task which fills every patriot's mind and heart today.

There has been some agitation against the promiscuous use of electric signs in various cities recently on the ground that the electric current they used needlessly increased the consumption of coal. Recently, L. A. Snead, Chief of the Division of Fuel Supplies of the Fuel Administration, said that no order to cease illuminating electric signs had been issued, although he had written the National Gas and Electric Association of Washington in reply to their request for larger supplies of coal to lighting companies, in which communication he suggested that they first put into effect economies such as the discontinuance of large street illuminations.

In the event of an order from the Government to this effect, it will supersede any ruling of the Public Service Commission, and the Fuel Administration is in a position to withhold the coal supply from any power or light company that refuses to comply with such a request or order.

These are not ordinary times and no one is wise enough to foretell just what is to occur before the war is ended. That there is difficulty now in obtaining coal is evident, and although it may appear a small matter to cut out lights here and there, a concerted action on the part of the small as well as the large consumer through the country will go a long way toward conserving the coal supply.

A large user of gaskets inquired recently where the reduction in asbestos and increase in cotton in asbestos gaskets were going to stop. Easy. Not until enough users are driven to gaskets of other materials. To lower the quality of such an important necessity as gaskets for high-pressure steam lines, instead of keeping up the quality and increasing the price, must be poor business because it is poor engineering.

The stress upon the railroads should be relieved by using to the limit the waterways of the country. The National Rivers and Harbors Congress is in session at Washington this week.

Correspondence

What of the Report of the Foul Murder of Dr. Diesel?

Did Dr. Diesel meet with German vengeance? Was he thrown overboard as reported in the daily press, referred to in *Power* on page 519, Oct. 16? His fair name has been aspersed as a suicide.

I believe that it is the duty of engineers to guard the reputation of the members of their profession, and I would be in favor of an investigation, by the A. S. M. E. or some other body, concerning the rumors and the accuracy of the newspaper reports in regard to the matter. If the facts justify further publicity, they should be published with a statement of the case.

W. T. MAGRUDER.

Columbus, Ohio. Ohio State University.

In *Power* for Oct. 16 appeared an article from the Hearst papers on the mystery of the death of Dr. Diesel, which article is not only contradictory, but also presents a story which is far from facts, and therefore, I believe, should not appear in a paper of the standing of *Power* because it is liable in later years to be quoted as *Power's*.

The author of this article states that Dr. Diesel left Munich in October, 1913, and then he states that the Doctor reached Antwerp, where he embarked for England on Oct. 1. I wonder how that is possible, especially as it is well known that Dr. Diesel lost his life on Sept. 29. Assuming this is only a mixing up of dates, there is another statement which goes to show that this whole report is a story built up in the mind of a daily-newspaper reporter who somewhere just caught a few words and made his story. He is quoting himself as asking Mr. Steinbrink (I suppose Mr. Steinbecker, of Messrs. Krupp, is meant), "Is it not true that he (Dr. D.) finds new capabilities for his oil engines every succeeding year?" Every engineer knows Dr. Diesel conceived the *idea* of the high-compression engine; but we must remember that the pioneer work on this engine was done by other people, and here we have to name in the first line Mr. Lauster, of Augsburg. It was the engineering works of Augsburg-Nuremberg and the Krupp Co. who took it into their hands to create and to develop a *commercial* engine. Augsburg, for instance, was working for a long time on a heavy-oil engine when Diesel still fought for his original idea of a coal-dust engine as originally offered to those two companies. A glance into the patent literature suffices to find out that the activity of the inventor had passed into other hands years ago, in this country as well as abroad.

Does any serious engineer believe the statement that the wonderful engines of a 2000-ton submarine were destroyed so as not to risk the discovery of a secret?

The author states that the Diesel engine was in use on all sorts of merchant vessels more than he was aware of at the time of his conversation with Mr. Steinbrink (?), which was before the war. This statement indicates that the author is very little informed on Diesel-engine matters, because there has never been made any secret about Diesel engines for merchantmen. What has been done along this line has always been published in detail, with drawings, in the technical papers. I personally took part in the development of the Diesel engine abroad and would be glad to give references to Diesel-engine literature.

It is my opinion that the author of such a report abuses his privileges of publication and the right of the American reading public to hear the facts and not "stories" such as reporting that Mr. Steinbrink (?) related that Dr. Diesel was pushed overboard in the interest of the German military machine. There is evidence enough to warrant the conclusion that the private affairs of Dr. Diesel probably account for his ending his life, if its ending was not accidental. But these affairs are outside of engineering.

There is one possibility that the author of the "story" wrote in good faith, and that is that he may have been in Germany, that he really had a conversation with an officer Steinbrink of the German Navy, who may have "made a fool" of the reporter, which is likely, for in their overbearing manner some German officers like to pretend that they know everything.

New York City. H. KERSH.

[Inquiry of the *Chicago Examiner*, in which the article referred to first appeared, brought out the following letter:

> In reply to yours of Oct. 1, the news item stating that Dr. Deisel had been murdered by order of the German military authorities was sent to us from London, where it was prepared by the Norwegian member of a former submarine crew of Germany. From time to time we have had other reports that Dr. Deisel had been murdered, and has also been currently referred to by America (the *American?*). Of course, it is impossible for us to furnish proof of these statements.
>
> We are inclosing you proof of an article from the New York *American* which we propose to print next Sunday.
>
> WALTER HOWEY,
> Day Managing Editor.

The proof referred to in the second paragraph alleges that the original article was untrue and reiterates the claim that Dr. Diesel committed suicide.—Editor.]

Dashpot Improves Governor Action

We had in our station three Corliss engines and three turbines, and they all ran well together except No. 1 Corliss, which would run all right with the turbines but not with the other reciprocating engines.

After considerable search it was decided that the cause was in the governor action. The other engines had dashpots attached to the governor stem but No. 1 did not, so when the load was thrown on or off suddenly, there was nothing to retard the action of the governor and it would fly open and grab most of the load or close and drop the load. A dashpot was attached to this governor, and the engines then worked better together.

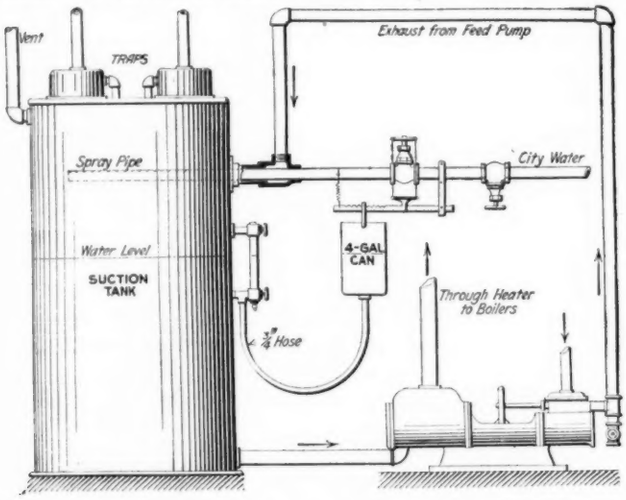
W. H. NOSTAN.

Philadelphia, Penn.

Easily Made Water Regulator

The illustration shows a water regulator I made for a feed-pump supply tank. I filed the threads off the stem of a 1½-in. globe valve and connected it in the make-up line so that the city pressure would come below the disk and raise it off the seat and let the water into the spray pipe, which was a piece of 1¼-in. pipe with one end welded shut. About 10 slots were cut across the top side with a hacksaw, so that the water would spray to the top of the tank and condense the exhaust steam from the feed pumps and the steam that leaked through the two traps that handled the condensation of two ammonia generators.

When the water in the 4-gal. regulating can got high enough, its weight would overcome the city pressure, close the valve and shut off the water to the tank. As



VARIABLE WEIGHT ON WATER-INLET VALVE

the water level would lower in the large supply tank, it would also lower in the 4-gal. regulating tank, which would decrease in weight and allow the city water to flow through the regulating valve into the supply tank.

Before I put this regulating valve and spray pipe in the tank, the water used to go into the boilers at 160 deg. F. Now it is always above 200 deg., and there is no more steam coming out of the vent pipe to make the boiler room damp. The tank does not run over, so I no longer get my feet wet. B. J. KATHER.

Chicago, Ill.

Professional (?) Engineers

Your editorial and the letter of William Chaddeck in the issue of Sept. 25 both touch on a matter that is of vital interest to the many thousands of operating engineers that subscribe to *Power*. Mr. Chaddeck says we have tried the "Learn More, Earn More" stunt and found it a failure, and he is perfectly correct in that statement. I also note that Mr. Chaddeck does not write "engineering profession" even once in his letter, and that certainly is an innovation in a letter from an engineer published in an engineering paper.

I often laugh quietly to myself when I think of the professors (?) who work twelve hours at night and then go home in the morning and go to bed to get sleep to enable them to stand another twelve hours, and the thermometer registering around the 90-deg. mark. These professors (?) certainly must be in good physical shape at such time to protect lives and property. I have seen some of them with an engineer's license on the wall operating 84 hours per week and doing their own firing for $15. And I have seen hodcarriers carrying bricks in the same boiler rooms, who received $17 for 48 hours' work and time-and-a-half for overtime. But Mr. Hodcarrier did not belong to an order that posed as an educational organization when its real object was to prevent the spread of unionism among engineers and to tell them that the low-paid trade of engineer is a profession, and that by some miraculous means they (the engineers) are to live in a sort of Utopia when we have some more license laws enacted. No, sir! Mr. Hodcarrier belonged to an organization whose sole object was to reduce the hours of labor and increase the wages of all hodcarriers, and they had no educational societies and no license laws.

Mr. Chaddeck's wage of $25 per week is above the average for a non-union engineer. The average wage in the eastern part of our country is nearer $16 for 84 hours' work. The writer worked in a "Learn More, Earn More" plant some years ago, not a hundred miles from Philadelphia. The engineers were paid $18 for seven days of twelve hours per day. The firemen got sixteen "iron men" for the same number of hours. The firm could not see its way clear to give us even one dollar more, so we all joined the union and, presto, the engineers received (after a conference between the employer and the union officials) $20 per week and an eight-hour day with ten days' vacation each year on full pay. The firemen received the same conditions as the engineers and $18 per week. Remember, we did not join the union till we had tried the "Learn More, Earn More" policy and found out that it does not work as it is advertised to do.

Of course, exceptional men get good wages, but for the common everyday operating engineers all over the United States—the men who actually operate the machinery in our factories, power houses, etc.—there is only one way to get decent hours and decent wages, and that is through the union. The men of other trades don't talk of professions. You never heard of the plumbing profession or the bricklaying profession, did you? I guess not! And when the engineers of America get wise to the fact that engineers are one of our poorest-paid tradesmen, when they recognize that organization is their only salvation, it will mark the dawn of a new and brighter era for the power-plant workers of the U. S. A. A UNION ENGINEER.

Somewhere in Connecticut.

Where Was the Air Leak?

A surface condenser during regular inspection was filled with water under 4- to 6-lb. pressure to test for leaks. The drop pipe leading to the vacuum gage became water-logged so that when the condenser was again put into service the gage showed only 17 inches.

Search was made during two days, of three watches each, for the supposed air leak before I thought to drain the "gooseneck" of water that caused the false reading. The gage then showed 27½ in., the true vacuum.

New York City. H. E. HOFFSTADT.

High Speed of Steam Turbines

In the Oct. 2 issue of *Power* there is an article on "High Speed of Steam Turbines" which, as the editor intimates, is open to discussion. This article has evidently been written from the power chief's point of view. It might be well to consider the matter from the designer's viewpoint. The stress calculations for the spindle of a steam turbine can be performed in a fairly exact manner. These calculations are computed for an overspeed of 20 per cent., as the turbine is subjected to this overspeed before leaving the test floor. Steel that has an elastic limit of 48,000 lb. per sq.in. is the material commonly used in the manufacture of medium-sized turbine spindles, and for this class of steel a working fiber stress of 25,000 lb. per sq.in. is conservative.

Overspeed Test on Reaction-Type Turbine

In the design of a reaction-type turbine there are several objections to an 80 per cent. overspeed test, which will become self-evident from an example. Consider the drum of a reaction turbine, and take for analysis a section well away from the end disks. A surface velocity of 350 ft. per sec. is not uncommon at normal speed. In a steel drum with no blade load, the tangential stress due to rotation is in accord with the formula $S = 0.104\ V^2$, where S is the stress in pounds per square inch and V is the velocity of the center of gravity of the section in feet per second. With $V = 350$ the stress at 20 per cent. overspeed will be 18,300 lb. per sq.in., and at 80 per cent. overspeed it approximates 41,300 lb. per sq.in. These stresses are due to the weight of the drum alone. With blade load the total tangential stress at 20 per cent. overspeed may be about 23,000 lb. per sq.in. and at 80 per cent. overspeed this value would become about 52,000 lb. per sq.in. The blading itself is worked with about the same factors of safety. At 20 per cent. overspeed the tensile stress across the blade section at the root will amount to about 16,000 lb. per sq.in., and at 80 per cent. overspeed would amount to approximately 36,000 lb. per sq.in. The latter value is practically the elastic limit of the blade material. In the reaction-type turbine it is customary to so design the spindle that its critical speed will be in the neighborhood of 30 per cent. above the normal speed. With an overspeed test of 80 per cent. the critical speed of the turbine is passed through; which would mean that very much lower stresses would be used in the design, or the grade of the steel increased. The former would naturally mean a heavier spindle.

In an impulse-type turbine the same objections to an 80 per cent. overspeed test would prevail. A blade speed of 650 ft. per sec. is common practice. As an example, consider a disk with a single row of blades. The highest local stress will probably be at the root of the lugs which form the T-shaped groove for fastening the blades. With steel that has an elastic limit of 48,000 lb. per sq.in. the fiber stress at this point may be 28,000 lb. per sq.in. at 20 per cent. overspeed, and at 80 per cent. overspeed this value might be increased to 63,000 lb. per sq.in. In the impulse blades the stresses across the blade section at the root are in the neighborhood of 35,000 lb. per sq.in. at 20 per cent. overspeed. At 80 per cent. overspeed this blade stress would become 78,800 lb. per sq.in. The blade material is commonly nickel steel, and its elastic limit is about 75,000 lb. per sq.in. The spindle of a large impulse-type turbine, as a rule, is designed to pass through the critical point. The spindle shaft, however, is made of a special steel, and the stresses are comparatively low in order to take care of the excessive vibration while passing through this point.

The factory tests to which the manufacturers generally subject their turbines are a brake test and an overspeed test of 20 per cent. On the large-sized turbines where there is not sufficient steam to bring the turbine up to speed, the brake test is omitted. The 20 per cent. overspeed test is easily obtained by direct-connecting a small turbine, passing enough steam through the large turbine to keep it hot, and then bringing the small machine up to the desired speed. This gives practically a service overspeed test to the large turbine, as the stresses due to the impact and reaction of the steam on the blading are negligible.

There are two separate and entirely independent appliances supplied with a turbine which are intended to make an 80 per cent. overspeed test unnecessary; namely, the governor, which for electric generation, controls the speed to about 1½ per cent., and an emergency-trip governor, which is set to shut off all steam from the turbine at about 10 per cent. overspeed. These emergency-trip governors are not infallible by any means, but when well designed and fairly treated by the operator, can be depended upon to operate well under the 20 per cent. overspeed of the turbine.

If an 80 per cent. overspeed test were insisted upon, it would mean either using a higher grade of steel and stronger blade fastenings, with an increased cost, or reducing the peripheral velocity, which for a given power would result in both a heavier and a less efficient machine, with an increased cost.

C. H. Watson.

Portland, Ore.

Pump Got Hot and "Froze"

Someone started the 16 x 9 x 12-in. fire pump one morning while the night man was out of the engine room, and as it had no water, it went so fast that one plunger "froze" fast to the sleeve. The pump was used regularly during the day for supplying water to the scouring machines, therefore it was up to me to get it going as quickly as possible. I tried to pull the plunger out with a screw, but it wouldn't budge, so I removed the sleeve gland and took out plunger and sleeve together. The problem still remained how to get the sleeve and plunger apart. I tried at several machine shops to get it done, but for one reason or another none of them could do it. I then called up the manufacturers in town, and they said they could not undertake it for a week or more on account of being too busy.

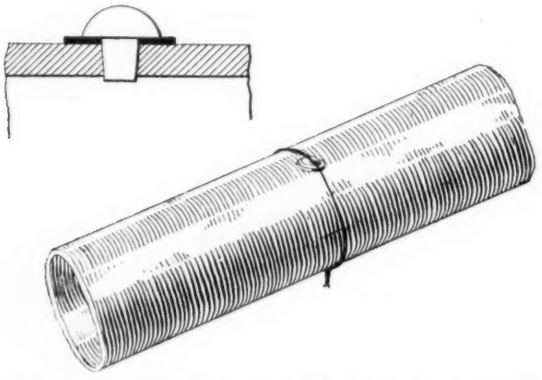
I had a piece of 10-in. pipe about three feet long that the sleeve would just fit into. The flange on the sleeve made a fine bearing to pull on, and after about two hours' hard work with a pulling bolt and a long wrench, we managed to pull the plunger out. I filed down the high places on the plunger and scraped the

inside of sleeve to a good fit, guided by a pair of calipers—a patience-trying job of four or five hours—and got the pump going that evening. The plunger is now as tight as the other one. If the job had been sent to the factory, we would have had to use city water at quite an expense, not to mention the cost of the work, and we would have been without fire protection for two weeks at least. I have found some helpful hints in *Power*, and this is my offering in return.

Boston, Mass. G. J. KELLEY.

Stopping Small Leaks in Pipes

I have had some trouble with the pitting of feed-water pipes. A leak will sometimes develop during a run when a shutdown is not to be thought of, and I have found the following a good way to repair them temporarily; in fact, it will some times last for months. First ream out the pin hole with some pointed tool (the



COPPER RIVET DRIVEN INTO PINHOLE IN PIPE

tang of a file is a good thing), then select a copper rivet slightly larger than the hole and put a washer of rubber on it and with a light hammer drive the rivet up tight until it binds on the packing. A piece of wire may be put around the pipe and over the rivet to secure the job. H. VIPOND.

Killarney, Man. Can.

Low Steam Rate Does Not Necessarily Mean Low Coal Consumption

[The following excerpt from a personal letter is interesting enough to share with our readers.—Editor.]

I attended a meeting of engineers some two months ago. Two gentlemen spoke, for whom I have much respect, and many young men were listening with great attention. One gentleman made the remark that we should be very careful in the use of fuel today—prices ranging so high—that everything should be done to utilize the byproducts and exhaust steam should be used for every purpose. He cited some things he had done, which they thought were wonderful. He did not tell them that this was nothing new.

One of Mr. Corliss' first engines was sold with the guarantee that he would pay $500 a ton for every ton of coal he burnt, more than they were burning with the condensing engine then in use. To the public surprise, he installed his engine and ran it noncondensing, and used the exhaust steam to heat the mills, do the slashing and heat the feed water, while his competitor used direct steam for everything. Of course he won out.

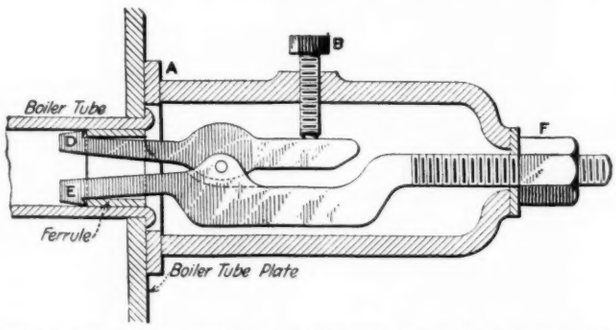
Another gentleman made the remark that small turbines were being developed today that would produce a horsepower-hour on 15 pounds of steam, and that by all means large turbines should be installed. I thought right off of a case with which I am familiar. Some day, some smart man will come along and tell them how much he can save by doing away with the antiquated plant and making everything modern. Let us see how much he could save. They have two pair of engines running cross-compound, and every bit of condensed water is stored in tanks and used in the finishing department. They sacrifice on the vacuum to keep their discharge water up to 110 deg., and every drop of this water is used and they could use more if they had it. Other engines develop about 3000 hp. running simple noncondensing. All that steam goes into the dyehouse, which is still crying for more! So you see, all the heat units from this antiquated plant are used. Now, how much could the modern man save by installing modern machinery? Of course, what he saved in difference over the whole plant would have to be made up directly from the boilers.

We should be very careful, when we recommend any changes, to see that they are adapted to the place in which they are to be used. Fortunes are wasted every year by failure to do this. The great reason that our manufacturing concerns are not running economically today is that we have two bad elements to contend with—the ignorance of the owner and the jealousy of the engineer in charge; because when you tell the engineer that he isn't running his plant economically, you are making an enemy of him. GEORGE H. DIMAN,

Lawrence, Mass. Consulting Engineer.

Boiler-Tube-Ferrule Puller

The boiler-tube-ferrule extractor shown in the illustration is being used in a locomotive shop and has the advantage of being cheap and easy to construct, is "husky" to stand abuse and is capable of adjustment to various sizes of boiler tubes. In using, a hard-steel washer *A* is first placed against the tube plate, setscrew



FERRULE EXTRACTOR IN POSITION READY FOR A PULL

B being slackened to allow the jaws *D* and *E* to enter, and when in position the setscrew *B* is advanced far enough to press the jaws against the sides of the boiler tube. Nut *F* is then turned with a wrench and the ferrule gradually drawn out. B. KAHN.

Chicopee, Mass.

Inquiries of General Interest

High-Voltage Line More Economical—To supply current for 50 to 100 incandescent lamps about one mile from the power house, would it be more economical to run wires for 2200-volt alternating current with a transformer near where the lights are to be used or run a 110-volt line from one of the transformers at the power house? What size of wire should be used? W. J. S.

It would be more economical to run a 2200-volt line and place the transformer near the load center. No. 10 B.w.g. iron conductor would be suitable.

Groaning of Steam Pump—What causes a steam pump to make a groaning noise, and how can the trouble be removed? H. C.

A groaning noise may be due to poor lubrication of the steam end, overtightening of the piston-rod packing, too tight water-piston packing or misalignment of the pump. Noise in the steam end often is reduced by the use of different cylinder oil or by the application of graphite mixed with cylinder oil forced into the cylinder with a hand pump. Whether the noise is due to the piston-rod packing being out of line and thereby pressing a piston against one side of its cylinder can be determined by running the pump with the piston-rod packing slackened.

Testing Capacity of Safety Valves—How can a practical test be made of the sufficiency of capacity of safety valves on a boiler? W. S.

The safety-valve capacity may be checked by making an accumulative test; that is, by shutting off all other steam-discharge outlets from the boiler and forcing the fires to the maximum. If the safety-valve equipment is capable of discharging all the steam that can be generated by the boiler without allowing the pressure to rise more than 6 per cent. above the maximum allowable working pressure for the boiler, or more than 6 per cent. above the highest pressure to which any safety valve on the boiler is set, then the capacity is sufficient.

Size of Steam Port for Corliss Engine—What should be the size of the admission ports for a 16-in. x 36-in. Corliss engine with single-ported valves running 100 r.p.m.? M. A. C.

Assuming the average speed of piston to be equal to the maximum speed during admission, combined with a nominal steam speed through the port of 7500 ft. per min., then $2 \times \frac{36}{12} \times 100 \times 16^2 \times 0.7854 = 7500 \times$ area of port in square inches; hence, area of port = 16.08 sq.in. As the length of Corliss engine ports is usually equal to the diameter of the cylinder, the size of the admission port should be 16.08 ÷ 16, or practically 1 in. wide by 16 in. long.

Meaning of "Vacuum"—What is really meant by a vacuum? J. A. J.

Theoretically, a vacuum is a space absolutely devoid of matter. Ordinarily, the term is applied to a space from which air, gases or vapors have been exhausted to a very high degree, like the space within the globe of an incandescent electric lamp. Such a space is not, however, a perfect vacuum, for some small quantity of gas or air remains.

In engineering, the term "vacuum" is commonly applied to a space in which the pressure is below the pressure of the atmosphere. Atmospheric pressure varies according to the elevation of the place and with different conditions of temperature and moisture of the atmosphere. Under normal conditions the pressure of the atmosphere at sea level is about 14.7 lb. per sq.in., which would be equal to the pressure required to sustain an unbalanced column of mercury 30 in. high when at 62 deg. F.

If at sea level the upper end of a barometer were to be connected into a condenser in which there was a perfect vacuum, the height of the column of mercury would be 30 in. If the absolute pressure in the condenser would support a column of mercury 4 in. high and the upper end of a barometer was connected with the same condenser, then the height of the barometric column would be 30 — 4 = 26 in., and it would be said that the pressure of the condenser was 26 "inches vacuum."

Material in Storage-Battery Plates—What is the active material in the plates of Exide storage-batteries and for what purposes are these batteries used? D. P. O.

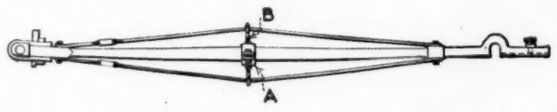
"Exide" is the trade-mark name of a group of batteries manufactured in this country. The name suggests the material "lead oxides," from which the active material of the positive and negative plates are made. In the case of the positive plate, the oxide of lead is changed to lead peroxide in the process of manufacture, while in the negative plate the oxide is changed to a finely divided form of pure lead known as "sponge lead."

One of the most interesting types of this plate is known as the "Ironclad-Exide" positive plate. It consists of a series of vertical rods or pencils having metal conducting cores integral with the top and bottom bars, surrounded by a layer of active material covered by a tube of hard rubber provided with numerous slits. These slits serve to provide access for the electrolyte to the active material and prevent the washing out of the material.

"Exide" batteries can be used for most purposes where storage batteries are used. One of the most important applications is their use for emergency service in the large power plants of the country to furnish power in case of failure of the regular generating equipment.

Vibration of Corliss-Engine Hook Rod—After fitting a Corliss engine with a new shaft and crank, the hook rod set up an intense vibration. What would be the cause and remedy? B. B. F.

A whipping vibration of long hook rods is likely to occur with excessive friction of the valves or valve gearing or may be induced by shocks or jars in any part of an engine, especially when the length and stiffness of the rod result in vibrations that time with the speed of rotation of the engine. If the vibrations began after a new crankshaft was provided and with all other conditions as before, they may arise from shocks due to lateral movement of the shaft in one of its boxes or of a box riding in its pedestal. If not practicable to cure the trouble by tightening the boxes and eccentric-rod connections or by reducing the friction of the valve gear, the whipping motion can be prevented by stiffening the rod with truss rods, as shown in the sketch.



TRUSS RODS FOR STIFFENING HOOK ROD

The clamp collar *A* placed on the rod midway between the enlargements of the ends has tapped holes for receiving two truss posts *B* that are provided with check-nuts for steadying the posts which have eyes in their outer ends for receiving tight truss rods. The truss rods have eyes at their ends for securing them by capscrews to the enlarged ends of the hook rod, and the rods are drawn up tight by turnbuckles, or by pipe swivels as shown.

Autogenous Welding as Allowed by Board of Supervising Inspectors

The following regulations relative to welding and reinforcing boilers have been announced by the Board of Supervising Inspectors of Steam Vessels of the United States Steamboat Inspection Service:

All calking edges on internally fired boilers may be reinforced by these processes.

Calking edges of the shells of externally fired boilers, above the fire line only, may be reinforced.

Cracks extending from edge of lap to rivet, except on seams below the fire line in externally fired boilers, may be welded.

Cracks not exceeding 30 in. in length in back connection sheets, wrapper sheets, bottoms of combustion chambers, heads and other stayed surfaces may be repaired by welding.

Where cracks are repaired by welding, holes shall be drilled entirely through the plate at each extreme end of the crack, except in small cracks from rivet to calking edge.

Circumferential or lengthwise cracks not exceeding 16 in. in length in plain or corrugated furnaces may be welded.

Where plates in back sheets of back connections, wrapper sheets of sides and bottoms of back connections of any boilers, side sheets and legs of furnaces and bottoms of furnaces of firebox boilers, and other stayed surfaces are reduced in thickness not exceeding 40 per cent. of the original thickness, they may be reinforced, such reinforcing not to exceed an area of 200 sq.in. in any one plate.

When such reinforcing extends over stays and braces, such stays and braces shall come completely through the reinforcing so as to be plainly visible to the inspectors.

When the corroded portion of stayed or riveted surfaces of the back sheets or wrapper sheets or bottoms of back connections of any boilers, or side sheets and bottom sheets of furnaces or legs of firebox boiler exceeds 300 sq.in., the same may be repaired by the removal of the corroded portion and the replacement thereof by a new piece of plate the edges of the new plate being welded in position.

Stay-bolts, braces or rivets shall pass through the body of the new plate as before, the area of the new piece not to exceed 24 in. by 24 in., or 30 in., in any one direction, the welded edges to be V'd or beveled along the joint prior to welding.

Thin Plates May Be Reinforced

Where plates of shells and other parts of internally fired boilers subject to tensile strain are reduced in thickness by corrosion not to exceed 25 per cent. of the original thickness, they may be reinforced, such reinforcing not to exceed an area of 200 square inches.

Where calking edges and laps have been reinforced, local inspectors shall require the rivets to be cut out and redriven if they find by inspection that it is necessary.

No welding shall be allowed in cracks in the shell plates or other plates subject to tensile strain.

Cracks extending through rivet holes in single-riveted or double-riveted seams in stayed surfaces of back connections of any boilers or side sheets, of legs or bottoms of firebox boilers which are stayed surfaces, may be welded up to a length of 6 ft. exclusive of rivet holes.

Where cracks extend through rivet holes in stayed surfaces, the piece extending from the rivet to the edge of the lap may be removed where convenient to do so, and the place where the piece has been removed may be replaced by being built up and reinforced by either of these processes.

Where leaks develop around stay-bolts and the stay-bolts are otherwise intact, the nuts may be removed from the ends of the stay-bolts and the stay-bolts may be welded into the shell by welding a beveled collar or ring around the stay-bolt. The width and depth of such collar shall equal one-half of the diameter of the stay-bolt. In all such cases of applying welding rings or collars around stay-bolts, the material shall be hammered while in a glowing state as it is applied.

In all cases where metal is deposited on stayed surfaces, the operator shall hammer, when practicable, the deposited metal while it is in a glowing state.

No repair work by any welding process shall be allowed until coupons showing the character of the work proposed to be done by the applicant have been tested and submitted, together with an explanation and report of the test, to the local inspectors of the district where the work is being done. The local inspectors shall then satisfy themselves whether or not such process can be used with safety on the boilers of steam vessels.

In every case where repairs are to be made by these processes on the boilers of steam vessels subject to the inspection of this service, the parties making the repairs are required to notify the office of the local inspectors, in writing, giving a full detailed description of the repairs to be made, the location of the vessel, and the time the repairs are to be begun, so that inspection may be had, if practicable, prior to and during the time the work is being done.

Cracks in wrought-iron or wrought-steel headers, and cracks or sand holes in cast-steel, semi-steel, ferro-steel, malleable-iron or castiron headers, manifolds, crosses, tees and ells may be repaired by welding cracks or flowing metal into sand holes. Such repaired material other than headers and manifolds shall be subjected to a hydrostatic test of 3½ times the working pressure after such repairs are made. Reinforcing by building up of any of the above-mentioned articles other than headers shall not be allowed.

When crown-bar bolts have deteriorated or wasted away at top of combustion chamber under the crown-bars, such deterioration not to exceed 25 per cent. of the original diameter of the bolt, such bolts may be built up or reinforced by any process of autogenous welding.

Where tube sheets of boilers have deteriorated not to exceed 25 per cent. of their original thickness, or where cracks have developed in tube sheets, the same may be reinforced and repaired by any process of autogenous welding, and the beading on the ends of tubes may be welded to the tube sheets by the same process. (Secs. 4405, 4418, R. S.)

Report on National Electrical Code Revision

On Mar. 28, 1917, the twenty-first annual meeting of the Electrical Committee of the National Fire Protective Association was called, at the rooms of the New York Board of Fire Underwriters, to consider committee reports and suggestions for changes in the National Electrical Code. However, at that time the meeting was postponed on account of an injunction secured by a fuse-manufacturing company preventing a discussion of these devices at the meeting. Since that time the injunction was set aside and the meeting scheduled for last March was held on Oct. 23 and 24, at the place mentioned, and the reports of the various committees and suggestions for changes in the code, as published in the Electrical Committee's Bulletin of Feb. 15, 1917, were considered.

The revised code should have been published early this year, but on account of the delay in considering the change it will not appear until early in 1918, and will be known as the National Electrical Code of 1918 instead of 1917 as intended. In view of this change the next revision of the code is scheduled to be made in 1920.

The meeting was shorter than usual, occupying only one and a half days. Chairman F. E. Cabot presided at all the meetings. At the close of the last session Mr. Cabot announced his resignation as chairman of the Electrical Committee, a position which he has filled for about 25 years. A vote of appreciation was tendered for his able guidance and coöperation during these many years. His successor was not named.

The committee on grounding presented a supplementary report dated Oct. 17, 1917, which was distributed at the meeting. This report was adopted practically as presented with the exception of the third paragraph of Section f, Rule 12, which was amended to read: "Metal conduit containing service wires must be grounded, as provided in

Rule 15a, except under the following conditions: (1) Conduits containing no conductors of circuits except 150 volts to ground may be left ungrounded if insulated from the ground and from the metal conductors, metal raceways or armored-cable systems within the building and from all other work on or in the building. (2) Conduits containing conductors of circuits exceeding 150 volts to ground may be left ungrounded if insulated as above and also isolated or guarded." The most radical change in this part of the code is in Rule 15, "Grounding Low Potential Circuits." This rule as now written contains only general provisions for grounding, and a new rule, 15a, "Methods of Grounding, When Protective Grounding Is Required," has been introduced. This rule contains a number of changes and is somewhat extensive, occupying a space equivalent to about eight pages in the old code.

Wiring of Power and Substations

The report of the committee on wiring of power and substations with one or two slight changes was approved as presented in the Feb. 15, 1917, report. The second paragraph of Section c, Rule 8, of the committee's report on induction motors was amended to read as follows: "Except for auto-starters, the switch called for in the preceding paragraph may be omitted where the motor starter disconnects all wires of the circuit. Where auto-starters are used, a switch must be provided on the supply side of each auto-starter. Where the starter, when in the running position, automatically opens under overload, it may serve also as a circuit-breaker." With one or two other unimportant changes, the report was approved as presented.

The opinion of this committee, as appended to the report, on the size of the conductors for a circuit supplying two or more motors is of general interest and is as follows: "The matter of the size of conductors for carrying the current of two or more motors has received the attention of the committee, and data on the subject have been collected. The data at hand indicate that the diversity factor of the load carried by the conductors for a reasonable period varies greatly and depends on the character of the motor load and the number and size of the motors. For this reason the committee does not feel warranted in recommending changes in the code along this line at the present time. The subject, however, will continue to receive consideration. Attention is called to the fact that there is nothing in the code to prevent the combined rated capacities of the motors connected to a conductor exceeding the safe current-carrying capacity of the conductor. Undoubtedly, there are many cases where a careful study of the conditions before installation will show that advantage may be safely taken of the diversity factor of the conductor load. It is necessary, however, that the conductors be properly protected by the circuit-breakers or fuses."

Fuses, Switches and Meter Installations

In the report of the committee on fuses, switches and meter installations, Rule 23 on automatic cutouts (fuses and circuit-breakers), Section a, caused considerable discussion and the wording was returned to the secretary for revision. The main idea in this section, it was decided, was that all meter installations be placed together to make a workmanlike arrangement and not be scattered in various parts of a building. In the rule on switches, a paragraph was rearranged to read as follows: "Service switches must be arranged to cut off the entire current from all circuits and devices, including meters, except as provided in the following paragraph. Where service fuses and meter are combined in an approved single self-contained unit device having no exposed wiring or live parts and no parts not protected by the fuses, the switch may be so arranged or installed that it will not disconnect the meter from the supply line, provided it does disconnect all lines of the supplied circuits."

The report of the switch and cutout committee was adopted with a few changes. Regarding the rule on refillable fuses, a notice was read that the suit brought last March by the Economy Fuse and Manufacturing Co., of Chicago, has been withdrawn. The committee reported: "In view of the misinterpretation placed on the report of the committee in the March bulletin regarding refillable fuses, the committee desires to submit the following revised report: On evidence presented to or obtained by the committee, it does not recommend any changes in Rule 68d, but presents this report with the understanding that in order to obtain additional field experience, municipal and underwriters' inspection departments may permit a continuation or extension of the use of such refillable fuses as have, in their opinion, been shown to comply with tests and specifications for cartridge fuses and to be suitable for use."

No action was taken upon the majority of the suggestions appearing under the general heading, "Miscellaneous Suggestions." Under Rule 8, Section c, a new paragraph is added: "Alternating-current motors operating freight or passenger elevators or cranes, that are dependent on phase relation for the direction of rotation, must be protected by approved automatic circuit-breakers (or reverse-phase relay), operative in the event of any phase reversal that would cause a reversed motor rotation, or in the event that the motor be connected in the line single-phase."

A new word, "raceways," has been introduced in the code to take the place of the word molding. This is on account of materials that have been introduced for running surface wiring in, which cannot be classed as molding or conduit. One of these materials is similar to the well-known metal molding except that the capping and base are in one part and the wires have to be fished into it. It is considered that the term raceways is broad enough to include any other materials of similar construction that may be developed.

Openings as Noncommissioned Army Officers

Able-bodied men between the ages of 18 and 40 are needed in the following branches of the Regular Army, where an excellent chance exists for rapid advancement to the positions of noncommissioned officers:

Infantry; Cavalry; Coast Artillery; Field Artillery; Medical Department; Signal Corps (only skilled cable, telegraph and radio operators, inside and outside wiremen, electricians, machinists, photographers, etc.); Quartermaster Corps (cooks and bakers, and, when special authority is granted, stenographers, typists and bookkeepers; no other applicants wanted in Quartermaster Corps); Ordnance Corps (where applicants bring authority from an ordnance officer); and Aviation Section of the Signal Corps.

There is a splendid opportunity for young men having any mechanical trade, or helpers therein, in the new engineer regiments or aëro battalions or quartermaster supply companies, and the like; and in such, any who have had military training or who are honorably discharged soldiers of the Regular Army or National Guard may be rapidly promoted to noncommissioned grades from which opportunities for training schools or commissions may be anticipated. If the applicants have no military training, the first to volunteer have the advantage of speedily becoming eligible therefor. Such vacancies are being rapidly filled, and any men under 40 who contemplate volunteering should lose no time in so doing.

A third series of officers' training camps will be organized on Jan. 5, 1918, with the object of training enlisted men of the Regular Army, National Army and National Guard for appointment as second lieutenants to fill vacancies that may occur in these forces. The graduates of these camps who may be so recommended, will be listed as eligibles for commissions as second lieutenants and will be commissioned as vacancies occur, provided that their services between the date of graduating and date of occurrence of vacancy has been satisfactory. Enlisted men between the ages of 21 and 40 are authorized to apply to attend, and their applications must be submitted before Dec. 1, 1917. No applications will be received after that date.

Members of the same club are urged to volunteer together, as it may be possible for them to be assigned to the same regiment or battalion. This has occurred in several instances, notably in Camden, N. J.

Attention is invited to circular received from Washington authorizing four stevedore regiments, Q. C., N. A., each to comprise 12 companies of 200 each (colored); also 16 fire truck and hose companies for duty at the N. A. division cantonments, each such to include 12 privates Q. C., etc. (white). Another order authorizes six Q. M. C. motor supply trains and 32 motor truck companies to include 7450 privates (white).

Further information and application blanks may be obtained from Maj. J. E. Bloom, 266 Market St., Newark, N. J., or write direct to the Chief of Engineers, or the Chief Signal Officer, or the Quartermaster General, Washington, D. C., setting forth your trade and military record and references, also age, whether single or married, and whether or not summoned by local examining board. Branches of the Newark Recruiting Office are located as follows: 269 Main St., Paterson; 215 Main Ave., Passaic; Post Office Building, New Brunswick; 1536 Atlantic Ave., Atlantic City; 136 Smith St., Perth Amboy; 55 Broad St., Elizabeth; 103 East State St., Trenton, and 540 Federal St., Camden.

The Army Recruiting Office, 266 Market St., Newark, recommends that mothers or wives of soldiers write to U. S. War Risk Insurance Bureau (Treasury Dept.) for any information pertaining to same.

Naval Reserve Receives Concrete Boat

A new addition to the equipment of the Great Lakes Naval Reserve was received Oct. 21, when a reinforced-concrete motor boat, the only one of its kind on the Great Lakes, was officially presented to the Naval Reserve at Chicago by Walter N. Dowsey, the owner and builder of the boat, which was built in 1914 and has been in use since.

Because of the present keen interest in all forms of boat construction, there has been considerable discussion as to the value of reinforced concrete for vessels. Recently, a large boat was floated at Norway, while reinforced-concrete vessels are now being built at Montreal, San Francisco and Seattle.

Mr. Dowsey's boat was built up with a T-bar laid for the keel, the end of which was turned upward and used for prow post. Flat steel 12 gage by 1 in. was riveted to the keel as ribs, on 12-in. centers. Some flat steel strips, 12-in. centers were then riveted to the ribs, extending lengthwise from prow to stern. Upon this light framework of flat steel in 12-in. strips, ¼-in. square wire mesh was attached by wire covering the entire hull, one thickness, and below water line and on the bottom, two thicknesses were used. No effort was made to trowel the outer surface of the hull smooth, and as a result she is not a real speedy boat, although she easily makes 10 miles an hour. The concrete was allowed to harden under cover and was sprinkled during the hardening.

The boat is 18 ft. 6 in. long, has a beam of 4 ft. 6 in., thickness of hull ¾ in., depth of hull 38 in.; power, 6-hp. motor. Portland cement and sand were used in proportions of one part of cement to 1½ parts of sand.

Technical Guildsmen for the Civic Ranks

In connection with or in response to the call of the President for volunteers, the attention of all technical men—that is, men skilled in any line of science or mechanical or electrical or chemical or ordnance or explosives or mining or shipbuilding or railroad or motors or metallurgy or building of airplanes or water-supply or sanitation, etc.—is especially invited to the need of the Army for such men, aged 18 to 40, in sundry branches of technical troops concerning which anyone interested may write for literature to Maj. J. E. Bloom, U. S. A., 266 Market St., Newark, N. J.

Any technical men who are "exempt" or who from any cause cannot volunteer can efficiently coöperate by forming technical patriotic educational guilds in their several industries or home neighborhoods, especially to look after the welfare of their men in the service and to give them the opportunity of obtaining technical assistance, opinions and advice from home, in any war industry, from time to time.

Tube Blowout Emphasizes Need of Automatic Nonreturn Valves

An explosion of a tube occurred on the morning of Oct. 23, in one of the horizontal water-tube boilers in the district heating plant, at Tenth and St. Charles Sts., of the Union Electric Light and Power Co., of St. Louis. It may be added to the already long list of similar accidents which appear as so many outstanding arguments in favor of providing every stationary boiler in high-pressure service with an automatic stop valve attached to the steam-outlet nozzle. The accident resulted in serious injury to three employees of the plant and caused a complete temporary shutdown of the group of boilers to which the damaged unit belongs.

The crippled boiler is of 350-hp. nominal capacity. It stands at one end of a row of six similar units comprising an installation of about 15 years' standing, and which is therefore lacking in some of the refinements of more recent boiler equipment. These six units are connected to a common header, ordinary gate valves being inserted in the connecting pipes for cutting the boilers in and out of service.

The ruptured tube, of 3½-in. size, was in the second horizontal row from the bottom. It let go without warning. It was found to have been ripped fore-and-aft for about two feet and to have been flattened out, the metal being torn round-about at each end of the lengthwise rip. The damaged portion of the tube was found free from any trace of scale or sediment, and there is nothing to indicate that a deposit of sediment of any kind was the initial cause of the accident. The boiler had been in service but a short time after the turbine cleaner had been run through the tubes, and the rupture showed no evidence of the preliminary bulging or bagging that would have taken place had the metal been overheated. The rupture occurred in the region where the products of combustion make their upward sweep around the end of the first baffle, and where, in consequence, their heating effect is concentrated by direct impingement upon the tubes.

At the time of the explosion the gage pressure was 125 lb. and all the boilers were being worked to their full capacity. For the time being it was impossible for anyone to reach the stop valve on top and cut the injured boiler off from the header, the difficulty of such an undertaking under the circumstances being augmented by the cramped location of the boilers. As a result the water in the five undamaged boilers was rapidly evaporated and drawn out by the action of the outrushing steam. When the pressure had dropped to about 15 lb., the water in the meantime having disappeared from the gages on all the boilers in the line and the fires having been partly drawn, a man wearing a gas helmet and further protected by a stream of cold water thrown upon him from a fire hose, succeeded in mounting to the top of the damaged boiler and closing the stop valve to stop the flow of steam from the other boilers.

How Inspector White Met His Death

The circumstances under which James White met his death while inspecting a boiler in Porto Rico, on Sept. 18, as noted in the issue of Sept. 25, page 441, have only recently been learned. It appears that Mr. White was in the act of entering the boiler preparatory to conducting an inspection, having passed his torch in ahead of himself, when an explosion of gas within the boiler took place and projected him out through the manhole and about 25 ft. into the air, killing him instantly. One leg was torn entirely from the body and the body was otherwise mutilated.

Mr. White was about 71 years of age, a member of the American Institute of Steam Boiler Inspectors, well and favorably known throughout this section of the country. It is likely that oil of a volatile nature, probably petroleum, had been used in the boiler for the purpose of loosening the scale to make it easier to remove. This is a common practice in some localities, and an extremely dangerous one. This accident again emphasizes the necessity of taking extra precaution to see that no oil capable of producing a gas is in the boiler before entering it with an open torch.

Measuring Brickwork

Brickwork is generally measured by 1000 bricks laid in the wall. In consequence of variations in size of bricks, no rule for volume of laid brick can be exact. The following scale is, however, a fair average:

7 common bricks to superficial foot	4-in. wall
14 common bricks to superficial foot	9-in. wall
21 common bricks to superficial foot	13-in. wall
28 common bricks to superficial foot	18-in. wall
35 common bricks to superficial foot	22-in. wall

Corners are not measured twice, as in stonework. Openings over 2 ft. square are deducted. Arches are counted from the spring. Fancy work counted 1½ bricks for 1. Pillars are measured on their face only.

A cubic yard of mortar requires 1 cubic yard of sand and 9 bushels of lime, and will fill 30 hods. One thousand bricks closely stacked occupy about 56 cu.ft. One thousand old bricks, cleaned and loosely stacked, occupy about 72 cu.ft.—*The Operative Miller.*

Heat from Electric Generators Utilized

One of the novel features of a hydro-electric power station in Norway described in *Engineering* (London) is the double effect incidental to cooling the 12,000-kv.-a. generators. The generators are entirely cased in, and the rotor is fitted with ventilation fans. The rotor draws the air either direct from the open, or if the weather is damp, the outside air is mixed with warm dry air from the machinery hall. The heated air is forced into the basement below the machinery hall, and from there it is distributed through different channels, either for heating the entire power station and instrument house, or the inspection tunnels of the dam, or it may be sent up to the crest of the dam for heating the oil-pressure installations of the throttle valves, or alternatively the air may be discharged directly into the open.

Longevity of Rope Drives—The longest known life of a rope drive in 24-hour service is one in England that was installed in September, 1878, in a Lancashire cotton mill (delivering 820 hp. at about 4400 ft. travel per minute) and is still doing satisfactory duty. It is a common thing, however, to find cotton ropes doing night and day duty for twenty years or over.—*J. Melville Alison, Manchester, England.*

Folly of Getting Mad

By S. F. Wilson

In screwing a globe valve into place a few years ago, I got mad because I bumped my elbow. Like a child, I struck it a heavy blow with the wrench and broke a hole through the casting. The valve was ruined and I had to buy another.

As a youngster I lived in a country town. Near-by there was a prosperous farmer who had the "best farm in the county." One day there was a terriffic so-called sandstorm, one of a number that spring, this one worse than usual. The farmer got mad and sold his farm for a song, stating that he "wouldn't live in such a country any longer." He moved to a distant clime, but did not like it, came back and had to start all over again.

An acquaintance went out in his high-priced car the other day and had engine trouble. He got mad. He traded the car for a very low-priced one that came along—an even trade. In less than five minutes the new owner had the high-priced car a-going and was off. My acquaintance now makes some mighty strong comments about himself and the manner in which he controls his temper.

And so it goes. I will wager that every reader can think of similar instances. There are very few people who have not acted in a similarly foolish manner.

It, therefore, is no surprise to me to read about men who have had trouble with gas engines, who got mad and who thereupon declared they would never have anything more to do with them. It seems to be human nature to act in such a manner once in a while; and after we "get our foot in it," we cannot very gracefully get out again and so we make the best of it.

Troubles with gas engines are bound to occur in the same way that troubles occur with other apparatus. Can you think of anything with which we ordinarily have to do that does not give trouble at some time or other?

There is no need to draw conclusions, because the conclusion is perfectly plain to us all.

Through the coöperation of manufacturers of steel plates or shapes, manufacturers of electric spot-welding apparatus and the United States Bureau of Standards, a program for the investigation of spot-welded joints has been undertaken. This work will be done to show the practicability of substituting spot welding for riveting in the assembling of steel structures of various types.—*Commerce Reports.*

New Publications

STEAM CHARTS—Also a table of theoretical jet velocities and the corrections of mercury columns, with fifty illustrative problems. By F. O. Ellenwood, Assistant Professor of Heat-Power Engineering, Cornell University, New York; John Wiley & Sons, Inc.; $1.

This work, which appeared about three years ago, has reached its first thousand and has been amplified for the second by the addition of a table giving the theoretical velocities in feet per second for each tenth of a B.t.u. up to 80 and a table of squares of numbers from 200 to 2000. The book is built around the charting of the physical properties of steam upon the total heat-specific volume plane, because of the fact that upon these two values could be plotted lines of constant pressure, entropy and quality, so that each pair of the five sets of lines will make clear intersections, which the total heat-entropy chart does not permit. In order to illustrate some of the uses of the charts and tables, a number of problems with their solutions have been added. The book also comprises a brief review of the fundamental principles, a supplementary chart enabling one to read the external work and to obtain therefrom the intrinsic heat, tables for the correction of mercury-column readings, etc.

Obituary

George Meisplay, chief engineer of the Galesburg (Ill) municipal water and light plant, was electrocuted while inspecting an electrical appliance on Oct. 20.

Miscellaneous News

Two Million Dollar Hydro-Electric Power Plant—An electrical power plant, which it is expected will eventually pull the Southern Pacific trains over the Siskiyou Mountains, is nearing completion at Copco, Calif., and may be opened on Dec. 1. The California-Oregon Power Co. has been working on this mammoth undertaking for three years, and the enterprise will cost about $2,000,000. The plant will generate 25,000 hp. at first and will later be increased to 50,000 hp. by a subsidiary station a quarter of a mile farther down on the Klamath River. The dam is of reinforced concrete, the foundation of which is drilled 142 ft. into the solid rock. It is 130 ft. high, 94 ft. wide at the bottom and 335 ft. wide at the top.

The Southern California Edison Co., at Big Creek, has announced that it will shortly add 42,500 hp. to its present capacity, making a total of 170,000 hp. More than $2,000,000 will be spent on this new addition. The 31-ft. additions to the three power dams on Huntington Lake have been completed and this increase of the height of the dam will permit at some future date the installation of penstocks for additional units of 16,500 kw. each in the two power plants now constructed, or a total of 66,000 kw., or about $85,000 hp. One-half of this amount is being installed at once. This increasing of the company's hydro-electric production is a result of the successful power negotiations with the City of Los Angeles, the forthcoming agreement with the City of Pasadena and the merger with other local power companies and their subsidiaries.

Personals

Edward A. Cordes, who has been master mechanic for Fairbanks, Morse & Co. for the last eleven years, has tendered his resignation to take effect on Nov. 1.

William A. Battey, who has been connected with the Shepard Electric Crane and Hoist Co. since its start in this field, as Eastern sales manager and sales director, will sever his active connection with the business on December 1, but will retain his interest in the company and continue as a director. W. C. Briggs who for the past 10 years has been associated with Mr. Battey in the company's New York office as sales engineer, will become district manager. Robert T. Turner will join the New York organization as sales engineer on Nov. 1.

Engineering Affairs

The New York Association of the American Society of Refrigerating Engineers will hold its next meeting at the Machinery Club, 50 Church St., New York, Nov. 12. Charles D. Dickermann, Jr., will speak on "Heat Transfer."

Business Items

The Laclede-Christy Clay Products Co. has moved its general office to Suite, 1673, Railway Exchange Building, St. Louis, Mo.

THE COAL MARKET

Boston—Current quotations per gross ton delivered alongside Boston points as compared with a year ago are as follows:

ANTHRACITE

	Circular[1]		Individual[1]	
	Nov. 1, 1917	One Year Ago	Nov. 1, 1917	One Year Ago
Buckwheat ..	$4.98—5.20	$2.05—3.20	$7.10—7.35	$3.25—3.50
Rice	4.40—4.65	2.50—2.65	6.65—6.90	2.70—2.95
Boiler	.....	.....	.....	.....
Barley	3.90—4.15	2.20—2.35	6.15—6.40	2.35—2.60

BITUMINOUS

Prices per gross ton for Boston delivery are as follows:

	F.o.b. Mines*		Alongside Boston†	
	Nov. 1, 1917	One Year Ago	Nov. 1, 1917	One Year Ago
Clearfields ...	$2.42—3.47	$3.00	.....	$4.25—5.00
Cambrias and Somersets...	2.42—3.47	3.10—3.85	.....	4.60—5.40

Pocahontas and New River, f.o.b. Hampton Roads, is $4, as compared with $2.85—2.90 a year ago; on cars Boston price is $8.50—8.75.
*All-rail rate to Boston is $2.60. †Water coal.

New York—Current quotations per gross ton f.o.b. Tidewater at the lower ports* as compared with a year ago are as follows:

ANTHRACITE

	Circular[1]		Individual[1]	
	Nov. 1, 1917	One Year Ago	Nov. 1, 1917	One Year Ago
Buckwheat ..	$3.95—4.65	$2.75	$5.10—5.30	$2.75—4.00
Rice	3.40—3.60	2.20	3.80—4.10	2.20—3.50
Barley	2.90—3.15	1.95	3.00—3.30	1.95—2.75

Quotations at the upper ports are about 5c. higher.

BITUMINOUS

	F.o.b. N. Y. Harbor	Mine
Pennsylvania	$3.65	$2.00
Maryland	3.65	2.00
West Virginia (short rate)	3.65	2.00

Based on Government price of $2 per ton at mine.

*The lower ports are: Elizabethport, Port Johnson, Port Reading, Perth Amboy and South Amboy. The upper ports are: Port Liberty, Hoboken, Weehawken, Edgewater or Cliffside and Guttenberg. St. George is in between and sometimes a special boat rate is made. Some bituminous is shipped from Port Liberty. The freight rate to the upper ports is 5c. higher than to the lower ports.

Philadelphia—Prices per gross ton f.o.b. cars at mines for line shipment and f.o.b. Port Richmond for tide shipment are as follows:

	Line		Tide	
	Nov. 1, 1917	One Year Ago	Nov. 1, 1917	One Year Ago
Buckwheat ...	$2.90	$2.00	$3.80	$2.90
Rice	2.40	1.25	3.40	2.15
Boiler	2.20	1.10	3.30	2.00
Barley	1.90	1.00	2.15	1.00

Pittsburgh—Price of steam coal per net ton f.o.b. mine, Pittsburgh district:

	Nov. 1, 1917	One Year Ago
Slack	$3.00—3.25	$4.25—4.50
Mine-run	3.00—3.25	4.25—4.50
¾-in.	3.50—3.75	3.35—3.85

Add 40c. per ton for freight charge to Pittsburgh.

Chicago—Current prices per net ton f.o.b. mines are as follows:

	Williamson and Franklin Counties	Saline and Harrisburg	West Virginia Smokeless	Springfield	Clinton and Sullivan Counties
Steam lump ..	$2.65	$2.65	$2.70	$2.65	$2.65
Lump	2.65	2.65	2.70	2.65	2.65
Egg	2.65	2.65	2.70	2.65	2.65
Nut	2.65	2.65	2.70	2.65	2.65
No. 1 nut....	2.65	2.65	2.70	2.65	2.65
No. 2 nut....	2.65	2.65	2.70	2.65	2.65
No. 3 nut....	2.65	2.65	2.70	2.65	2.65
No. 1 washed.	2.65	2.65	2.70	2.65	2.65
No. 2 washed.	2.65	2.65	2.70	2.65	2.65
Mine-run	2.40	2.40	2.40	2.40	2.40
Screenings	2.15	2.15	2.20	2.15	2.15

Hocking lump, $2.60; splint lump, $2.40.

Northern Illinois thin vein—Prepared sizes, $2.65; mine-run, $2.40; screenings, $2.15.

St. Louis—Prices pet net ton f.o.b. mines a year ago as compared with today are as follows:

	Williamson and Franklin Counties		Mt. Olive and Staunton		Standard	
	Nov. 1, 1917	One Year Ago	Nov. 1, 1917	One Year Ago	Nov. 1, 1917	One Year Ago
6-in. lump ..	$2.35	$2.75	$2.35*	$1.85	$2.35	$1.75
2-in. lump ..	2.35	2.75	2.35*	1.75	2.35	1.50
Steam egg...	2.35	2.75	2.35*	1.75	2.35	1.50
Mine-run ...	2.10	1.75	2.10*	1.35	2.10	1.35
No. 1 nut...	2.35	2.75	2.35*	1.75	2.35	1.50
2-in. screen..	1.85	1.20	1.85*	1.10	1.85	.90
No. 5 washed	1.85	1.00	1.85*	1.00	1.85	.99

*Strike.
Williamson-Franklin rate St. Louis, 72½c.; other rates, 57½c.

Birmingham—Current prices per net ton f.o.b. mines are as follows:

	Mine-Run	Lump and Nut	Slack and Screenings
Big Seam	$1.90	$2.15	$1.65
Pratt, Jagger, Corona....	2.15	2.40	1.90
Black Creek, Cahaba	2.40	2.65	2.15

Government figures.

[1]Individual prices are the company circulars at which coal is sold to regular customers irrespective of market conditions. Circular prices are generally the same at the same periods of the year and are fixed according to a regular schedule.

PROPOSED CONSTRUCTION

Ga., Dublin—City has plans under consideration for the extension of its electric-lighting and power plant.

Ill., Chicago—The Chicago Rawhide Co., 1301 Elston Ave., will construct a boiler and engine house and install new machinery in same. Estimated cost, $10,000.

Ill., Ft. Madison—The Atchison, Topeka and St. Fe Ry., plans to build a new power plant within its grounds at Shopton. C. F. W. Felt, Chicago, Ch. Engr.

Ill., Millstadt—City is having plans prepared by the Fuller-Coult Eng. Co., Chemical Bldg., St. Louis, Mo., for improving its light plant. Estimated cost, $10,000.

Iowa, Sac City—City has retained G. J. Long, Engr., Webster City, to prepare plans for the construction of an electric-lighting plant here. Estimated cost, $60,000.

Kan., Norton—City plant plans to install a new engine in the electric-lighting plant. Estimated cost, $12,000.

Ky., Benham—The United States Coal and Coke Co., Benham, plans to build an electric lighting plant.

Ky., Covington—The Roy C. Whayne Supply Co. is in the market for a 3-drum hoisting engine, 10 x 12 in.

Mass., Fitchburg—The trustees of the Burbank Hospital plan to build a boiler house in connection with some new additions. Kendall Taylor & Co., 93 Federal St., Boston, Arch.

Mich., Traverse City—The Boardman River Electric Light and Power Co. plans to rebuild its power plant which was recently destroyed by an explosion. Estimated cost, $50,000.

Minn., Montevideo—The Northern States Power Co., Chicago, plans to build a 2-story, 25 x 40-ft. brick plant.

Miss., Magee—The State Tuberculosis Sanatorium is having plans prepared by B. Price, Arch., Empire Bldg., Birmingham, Ala., for the erection of an electric-lighting plant here.

Mo., Versailles—City plans to rebuild its electric-light plant, which was destroyed by fire.

Neb., Tobias—An election will soon be held to vote on a bond issue for an electric-lighting plant.

N. J., Atlantic City—The Atlantic City Electric Co., Arnold Bldg., has been granted permission by the Board of Utility Commissioners to issue $58,000 in bonds; the proceeds to be used in extensions and improvements.

N. Y., Buffalo—The New York Central R.R., Grand Central Terminal, New York, is having plans prepared for the erection of a new power house at its local plant on Curtiss St. Estimated cost, $30,000. G. W. Kittredge, Ch. Engr.

N. Y., Niagara Falls—The Kellogg Products Co., Buffalo, is having plans prepared for the construction of a new power house on Stephenson St.

N. C., Warrenton—City is having plans prepared for the erection of an electric-lighting plant with a 300 kw. capacity. A. G. Elliott, City Mgr.

Ohio, Cleveland—The Rubay Co., 1328 West 78th St., will construct a boiler house. Estimated cost, $6000.

Okla., Miami—City voted in favor of a $45,000 bond issue for electric-light improvements. Noted Oct. 7.

Penn., Erie—The Erie Forge Co., 15th and Cascade Sts., has had plans prepared by Day & Zimmerman, Engrs., 611 Chestnut St., Philadelphia, for the erection of a new power plant here.

Penn., Sharon—The Shenango Valley Electric Light Co., 63-65 State St., plans to issue $40,000 in bonds, the proceeds to be used in extensions and improvements. C. Kemery, Supt.

S. C., Holly Hill—The Holly Hill Electric Service Co., recently organized, plans to build an electric-light and ice plant here. The incorporators are H. W. Pearce, S. P. Wells and L. R. Rhame.

S. D., Highmore—City voted in favor of a bond issue for the installation of an electric-lighting plant here.

Tex., Bowie—City voted $15,000 bonds in a recent election for the construction of an electric-light and power plant.

Tex., Decatur—City plans to install new machinery, including an engine, in its electric-lighting plant.

W. Va., Charleston—The West Virginia Water and Electric Co. plans to erect a 1-story, 46 x 75-ft. power house addition to its plant. James Montgomery, Coyle and Richardson Bldg., Arch.

W. Va., Kingwood—The Preston County Power Co. plans to extend and improve its system here.

W. Va., Triadelphia—The Town Council has plans under consideration for the erection of an electric-lighting system.

Ont., Chapleau—W. A. McMitchell will receive bids until Nov. 15 for 1 turbine pump with a 400-gallon capacity, to be operated by a 40-hp. motor.

Ont., Toronto—The Palmolive Soap Co., Toronto, plans to erect a power-house addition to its plant on Natalie St. Estimated cost, $5000.

Ont., Toronto—The Toronto Carpet Manufacturing Co., King St., W., plans to build an addition to its boiler house. Estimated cost, $5000.

Prices—Materials and Supplies

These are prices to the power plant by jobbers in the larger buying centers east of the Mississippi. Elsewhere the prices will be modified by increased freight charges and by local conditions.

ELECTRICAL SUPPLIES

KNIFE SWITCHES—Following are net prices each in cities named for knife switches mounted on slate base, front connected, punched clip type, 250 volts:

	30 Amp.	60 Amp.	100 Amp.	200 Amp.
D. P. S. T. fuseless	$0.52	$0.93	$1.90	$3.42
D. P. S. T. fused	.81	1.37	2.70	5.14
D. P. D. T. fuseless	.88	1.52	3.42	5.70
D. P. D. T. fused	1.67	2.58	5.62	9.88
T. P. S. T. fuseless	.78	1.40	2.86	5.14
T. P. S. T. fused	1.22	2.05	4.18	7.70
T. P. D. T. fuseless	1.37	2.35	5.24	8.82
T. P. D. T. fused	2.68	4.13	8.99	15.80

Lots $25 and more, list.

FUSES—Following are net prices of 250-volt inclosed fuses each, in standard packages, in cities named:

0-30 amperes ..... $0.11¼ each 110-200 amperes ..... $0.90 each
31-60 amperes ..... .15¾ each 225-400 amperes ..... 1.62 each
61-100 amperes .... .40 each

FUSE PLUGS (MICA CAP) PER 100

0-30 amperes.. 4c. each in standard package quantities (500)
0.30 amperes.. 5c. each for less than standard package quantities (500)

SOCKETS, B. B. FINISH—Following are net prices in cents each in standard packages:

⅛-IN. OR PENDANT CAP			⅜-IN. CAP		
Key	Keyless	Pull	Key	Keyless	Pull
22.10c.	21.00c.	42.00c.	27.30c.	26.20c.	46.20c.

Note—Less than standard package quantities, 15% off list.

CUT-OUTS—Following are net prices each in standard-package quantities:

CUT-OUTS, PLUG

S. P. M. L.	$0.11	T. P. to D. P. S. B.	$0.24
D. P. M. L.	.18	T. P. to D. P. T. B.	.38
T. P. M. L.	.26	T. P. S B.	.33
D. P. S. B.	.19	T. P. D. B.	.54
D. P. D. B.	.37		

CUT-OUTS, N. E. C. FUSE

	0-30 Amp.	31-60 Amp.	60-100 Amp.
D. P. M. L.	$0.33	$0.84	$1.68
T. P. M. L.	.48	1.20	2.40
D. P. S. B.	.42	1.05	....
T .P. S. B.	.81	1.80	....
D. P. D. B.	.78	2.10	....
T. P. D. B.	1.35	3.60	....
T. P. to D. P. D. B.	.90	2.52	....

ATTACHMENT PLUGS—Price each, in standard packages:

		Standard Package
Hubbell porcelain	$0.21	250
Hubbell composition	.12	50
Benjamin swivel	.12	..
Current taps	.35	50

CHRISTMAS TREE LIGHT OUTFITS—For 110-volt lighting circuits the price is as follows:

	Per Set
8-light outfit with colored lamps complete	$2.00
16-light outfit with colored lamps complete	4.00
24-light outfit with colored lamps complete	6.00
32-light outfit with colored lamps complete	8.00
For 3½-volt battery circuits:	
8-light outfit with colored lamps complete	1.50

FLEXIBLE CORD—Price per 1000 ft. in coils of 250 ft.:

No. 18 cotton twisted	$21.50
No. 16 cotton twisted	29.00
No. 18 cotton parallel	24.00
No. 16 cotton parallel	36.00
No. 18 cotton reinforced heavy	28.50
No. 16 cotton reinforced heavy	39.40
No. 18 cotton reinforced light	24.00
No. 16 cotton reinforced light	32.00
No. 18 cotton Canvasite cord	21.75
No. 16 cotton Canvasite cord	32.00

LOOM—Price per 100 ft., in coils:

	Ft. in Coil			Ft. in Coil	
¼	250	$2.25	¾	150	$7.00
⅜	250	3.50	1	100	10.00
½	200	4.50	1¼	100	12.00
⅝	200	5.75	1½	100	15.00

RUBBER-COVERED COPPER WIRE—Per 1000 ft. in New York:

No.	Solid, Single Braid	Solid, Double Braid	Stranded, Double Braid	Duplex
14	$11.00	$12.75	$16.00	$25.00
12	15.50	17.88	21.00	35.16
10	21.75	24.50	27.50	48.50
8	30.50	33.75	38.25	67.00
6	....	....	58.76	....
5	....	....	69.20	....
4	....	....	83.10	....
3	....	....	100.00	....
2	....	....	121.25	....
1	....	....	158.75	....
0	....	....	191.60	....
00	....	....	233.75	....
000	....	....	286.00	....
0000	....	....	349.50	....

COPPER WIRE—Prices per 1000 ft. for rubber-covered wire in following cities:

	Denver			St. Louis			Birmingham		
No.	Single Braid	Double Braid	Duplex	Single Braid	Double Braid	Duplex	Single Braid	Double Braid	Duplex
14	$12.25	$15.20	$29.75	$13.50	$18.00	$30.00	$15.40	$17.90	$36.80
10	24.50	27.70	54.95	27.25	30.10	....	30.80	34.30	67.60
8	34.90	38.50	76.80	38.45	42.45	....	42.85	46.85	....
6	....	59.10	....	....	65.35	....	69.60	74.10	....
4	....	85.15	....	....	93.65	....	101.75	106.55	....
2	....	127.50	....	....	140.50	....	156.50	103.00	....
1	....	165.35	....	....	182.50	....	201.00	209.50	....
0	....	198.55	....	....	241.50	....	276.00	285.00	....
00	....	267.05	....	....	294.50	....	317.00	330.00	....
000	....	327.35	....	....	360.50	....	417.00	478.50	....
0000	....	399.60	....	....	439.50	....	508.00	516.50	....

CONDUITS, ELBOWS AND COUPLINGS—Following are warehouse net prices per 1000 ft. for conduit and per unit for elbows and couplings:

	Conduit		Elbows		Couplings	
In.	Enameled	Galvanized	Enameled	Galvanized	Enameled	Galvanized
½ ..	$69.70	$74.80	$0.1672	$0.1786	$0.0616	$0.0658
¾ ..	92.00	98.90	.22	.235	.088	.094
1 ..	136.00	146.20	.3256	.3478	.1144	.1222
1¼ ..	184.00	197.80	.4185	.4496	.1581	.1698
1½ ..	220.00	236.50	.558	.5994	.1953	.2098
2 ..	296.00	318.20	1.023	1.10	.2604	.2797
2½ ..	468.00	503.10	1.674	1.80	.372	.3996
3 ..	612.00	657.90	4.464	4.79	.558	.5994
3½ ..	763.60	818.80	9.86	10.59	.744	.7992
4 ..	926.50	991.90	11.39	12.23	.93	.999

Standard lengths rigid, 10 ft. Standard lengths flexible, ½ in., 100 ft. Standard lengths flexible, ¾ to 2 in., 50 ft.

LOCKNUTS AND BUSHINGS—Following are net prices in standard packages, which are: ½-in., 1000; ¾- to 1¼ in., 100; 1½- to 2-in., 50:

	Locknuts Per 100	Bushings Per 100	Flexible Conduit Box Connections Per 100
½	$1.02	$1.68	$5.62
¾	1.75	4.00	7.12
1	3.00	6.15	10.50
1¼	5.00	8.20	15.00
1½	7.50	10.25	22.50
2	10.00	16.40	30.00
2½	12.30	24.60	67.50

ARMORED CABLES AND BOX CONNECTORS—Following are net prices per 1000 ft. cable and standard package of 100 box connectors in single and double strip:

Wire Gage	Twin Conductor— Cable	Twin Conductor— Connectors	Three Conductor— Cable	Three Conductor— Connectors
14	$76.00	$4.50	$103.50	$4.50
12	101.25	4.50	127.50	4.50
10	138.75	4.75	176.25	4.75
8	176.20	5.75	247.50	6.00
6	277.50	6.25	362.40	7.50
4	431.25	7.50	....	....

LAMPS—Below are present quotations in less than standard package quantities:

Straight-Side Bulbs				Pear-Shape Bulbs			
Mazda B— Watts	Plain	Frosted	No. in Package	Mazda C— Watts	Clear	Frosted	No. in Package
10	$0.27	$0.30	100	75	$0.65	$0.70	..
15	.27	.30	100	100	1.00	1.05	24
25	.27	.30	100	300	3.00	3.10	24
40	.27	.30	100	500	4.50	4.65	12
50	.27	.30	100	750	6.00	6.25	8
60	.36	.40	100	1000	7.00	7.25	8

Standard package quantities are 10% from above prices. Yearly contracts ranging from $150 up allow a discount of 17% from list.

WIRING SUPPLIES—New York prices for tape and solder are as follows:

Friction tape, ⅙-lb. rolls	35c. per lb.
Rubber tape, ½-lb. rolls	45c. per lb.
Wire solder, 50-lb. spools	35c. per lb.
Soldering paste, 1-lb. cans	50c. per lb.

MISCELLANEOUS

HOSE—

	Fire 50-Ft. Lengths
Underwriters' 2½-in.	70c. per ft.
Common, 2½-in.	40-10%

	Air		
	First Grade	Second Grade	Third Grade
¾-in., per ft.	$0.55	$0.30	$0.25

Steam—Discounts from list

First grade... 30% Second grade... 30-5% Third grade... 40-10%

RUBBER BELTING—The following discounts from list apply to transmission rubber and duck belting:

Competition ..... 50-10% Best grade 25%
Standard 40%

LEATHER BELTING—Present discounts from list in the following cities are as follows for cut lengths:

	Medium Grade	Heavy Grade
New York	40%	35%
St. Louis	45%	40%
Chicago	30+10%	40+5%
Birmingham	35%	35%
Denver	40%	35%

RAWHIDE LACING—40%.

PACKING—Prices per pound:

Rubber and duck for low-pressure steam	$0.77
Asbestos for high-pressure steam	1.54
Duck and rubber for piston packing	.88
Flax, regular	.66
Flax, waterproofed	.99
Compressed asbestos sheet	.99
Wire insertion asbestos sheet	1.21
Rubber sheet	.55
Rubber sheet, wire insertion	.88
Rubber sheet, duck insertion	.44
Rubber sheet, cloth insertion	.25
Asbestos packing, twisted or braided, and graphited, for valve stems and stuffing boxes	1.10
Asbestos wick, ½- and 1-lb. balls	.65 to .70

PIPE AND BOILER COVERING—Below are discounts and part of standard lists:

PIPE COVERING		BLOCKS AND SHEETS	
Pipe Size	Standard Thickness Per Lin.Ft.	Thickness	Price per Sq.Ft.
1-in.	$0.27	½-in.	$0.27
2-in.	.36	1 -in.	.30
6-in.	.80	1½-in.	.45
4-in.	.60	2 -in.	.60
3-in.	.45	2½-in.	.75
8-in.	1.10	3 -in.	.90
10-in.	1.30	3½-in.	1.05

85% magnesia high pressure ..... 15% off

For low-pressure heating and return lines { 4-ply ..... 58% off; 3-ply ..... 60% off; 2-ply ..... 62% off

GREASES—Prices are as follows in the following cities in cents per pound for barrel lots:

	New York	Denver	Chicago	Birmingham	St. Louis
Cup	5 to 7	9½	7½	5½	5.6
Fiber or sponge	5 to 7	15	7¾	12½	5.9
Transmission	5 to 7	13	6¼	12½	5.9
Axle	3 to 7	5	5	4½	3.3
Gear	4 to 5	4½	6½	10½	6
Car journal	5½ to 7¼	4	6	9	3.75

COTTON WASTE—The following prices are in cents per pound:

	New York			
	Nov. 1, 1917	One Year Ago	Cleveland	Chicago
White	11.00 to 13.00	10.00 to 12.00	16.00	14.00 to 15.00
Colored mixed	8.50 to 12.00	7.00 to 9.00	14.00	10.00 to 12.00

WIPING CLOTHS—In Cleveland the jobbers' price per 1000 is as follows:

13¼ x 13¼ ..... $35.00 13¼ x 20½ $45.00

In Chicago they sell at $30@33 per 1000.

LINSEED OIL—These prices are per gallon:

	New York		Cleveland		Chicago	
	Nov. 1, 1917	1 Year Ago	Nov. 1, 1917	1 Year Ago	Nov. 1, 1917	1 Year Ago
Raw in barrels	$1.16	$0.88	$1.15	$0.97	$1.17	$0.92
5-gal. cans	1.26	.98	1.25	1.07	1.27	1.02

WHITE AND RED LEAD in 500-lb. lots sell as follows in cents per pound:

	Red				White			
	Nov. 1, 1917		1 Year Ago		Nov. 1, 1917		1 Yr. Ago	
	Dry	In Oil	Dry	In Oil	Dry and In Oil		Dry and In Oil	
100-lb. keg	12.25	12.50	10.50	11.00	12.00		10.50	
25- and 50-lb. kegs	12.50	12.75	10.75	11.25	12.25		10.75	
12½-lb. keg	12.75	13.00	11.00	11.50	12.50		11.00	
1- to 5-lb. cans	14.25	14.50	12.50	12.50	14.50		12.50	

RIVETS—The following quotations are allowed for fair-sized orders from warehouse:

	New York	Cleveland	Chicago
Steel ⅞ and smaller	30%	30%	40%*
Tinned	30%	30%	40%*

*For less than keg lots the discount is 35%.

Button heads, ¾, ⅞, 1 in. diameter by 2 in. to 5 in. sell as follows per 100 lb.:

New York ..... $7.00 Cleveland ..... $6.85 Chicago $5.50

Coneheads, same sizes:

New York ..... $7.10 Cleveland ..... $6.95 Chicago $5.60

AMMONIA—Below are prices per lb. in cities named:

	New York	Chicago	St. Louis
26-deg. U.S.P. carboys of 100 lb.	15c.	10c.	....
26-deg. U.S.P. drums of 1000 lb.	13c.	8c.	10½c.

Anhydrous ammonia in 100-lb. cylinders costs 30c. per lb. in St. Louis, Chicago and New York.

FIRE BRICK—Quotations on the different kinds in the cities named are as follows, f.o.b. works:

	New York	Chicago
Silica brick, per 1000	$50.00 to 55.00	$50.00
Fire clay brick, per 1000, No. 1	45.00 to 55.00	.....
Magnesite brick, per net ton	135.00 to 145.00	.....
Chrome brick, per net ton	135.00	.....
Deadburned magnesite brick, per net ton	85.00 to 90.00	.....
Special furnace chrome brick, per net ton	60.00 to 70.00	60.00 to 80.00

Standard size fire brick, 9 x 4½ x 2½ in. The second quality is $4 to $5 cheaper per 1000.

St. Louis—High grade, $55 to $65; St. Louis grade, $40 to $50.
Birmingham—Fire clay, $25 to $30; Denver, $23, per 1000.
Chicago—Second quality, $25 per ton.

FUEL OIL—Price variable, depending upon stock. New York quotations not available owing to this fact. In Chicago and St. Louis the following prices are quoted:

	Chicago	St. Louis
Domestic light, 22-26 Baumé	5¼c.	4½–4¾c.
Mexican heavy, 12-14 Baumé	7c.	3½c.

Note—There is practically no fuel oil in Chicago at present time.

OIL—Price per 50-gal. bbl. is as follows:

City	Fuel	Black	Red Engine	Steam Cylinder	Gasoline
Seattle	$1.60	$6.25	$11.00	$21.00	$10.25
Los Angeles	1.45	6.50	12.00	26.00	10.00
Denver	3.25	8.75	17.00	24.00	12.00
*St. Paul	3.00	5.50	11.00	17.50	10.05
Boston	5.50	10.50	15.00	20.00	12.50
Kansas City	7.20	5.20	10.50	17.85	10.15

Note—Standard prices of oil are necessarily difficult to give. Those above are for average grades.
*These are last month's quotations; current prices not available.

POLES—Prices on Western red cedar poles:

	New York	Chicago	St. Louis	Denver
6 in. by 30 ft.	$5.59	$4.94	$4.94	$4.32
7 in. by 30 ft.	7.40	6.60	6.60	5.80
7 in. by 35 ft.	10.70	9.60	9.60	8.55
8 in. by 35 ft.	12.20	10.90	10.90	9.65
7 in. by 40 ft.	12.35	11.00	11.00	9.75
8 in. by 40 ft.	13.75	12.15	12.15	10.65
8 in. by 45 ft.	18.20	16.20	16.20	14.30
8 in. by 50 ft.	21.85	19.45	19.45	17.15

PIPE—The following discounts are for carload lots f.o.b. Pittsburgh; basing card of May 1, 1917, for steel pipe, of July 2 for iron pipe:

BUTT WELD

Steel			Iron		
Inches	Black	Galvanized	Inches	Black	Galvanized
⅛, ¼ and ⅜	42%	15½%	¾ to 1½	33%	17%
½	46%	31½%			

LAP WELD

2	42%	29½%	2	26%	12%
2½ to 6	45%	32½%	2½ to 6	28%	15%

BUTT WELD. EXTRA STRONG PLAIN ENDS

⅛, ¼ and ⅜	38%	20½%	¾ to 1½	33%	18%
½	43%	30½%			
¾ to 1½	47%	34½%			

LAP WELD. EXTRA STRONG PLAIN ENDS

2	40%	28½%	2	27%	14%
2½ to 4	43%	31½%	2¼ to 4	29%	17%
4½ to 6	42%	30½%	4½ to 6	28%	16%

Note—National Tube Co. quotes on basing card dated Apr. 1.

Stock discounts in cities named as as follows:

	New York		Cleveland	
	Black	Galvanized	Black	Galvanized
¾ to 3 in. steel butt welded	38%	22%	38%	25%
3½ to 6 in. steel lap welded	18%	List + 20%	23%	39%

	Chicago		St. Louis	
	Black	Galvanized	Black	Galvanized
¾ to 3 in. steel butt welded	38.8%	24.8%	34.27%	19.27%
3½ to 6 in. steel lap welded	42.8%	27.8%	27.27%	13.27%

Malleable fittings, Class B and C, from New York stock sell at list price. Cast iron, standard sizes, 15 and 5%.

BOILER TUBES—Nominal discounts on less than carload lots freight added to point of delivery, effective from Nov. 1, 1916, on standard charcoal iron tubes and from Apr. 2, 1917, on lap-welded steel tubes are as follows:

Lap Welded Steel		Standard Charcoal Iron	
1¾ and 2 in.	31%	1½ in.	23%
2¼ in.	28%	1¾ and 2 in.	35%
2½ and 2¾ in.	34%	2¼ in.	32%
3 and 3¼ in.	34%	2½ and 2¾ in.	38%
3½ to 4½ in.	34%	3 and 3¼ in.	43%
5 and 6 in.	33%	3½ to 4½ in.	....
7 to 13 in.	30%	5 and 6 in.	37%
		7 to 13 in.	34%

Above discounts apply to standard gages and to even gages not more than four gages heavier than standard, in standard lengths. Locomotive and steamship special charcoal grades bring higher prices: 1¾ in., over 18 ft. and not exceeding 22 ft., 10 per cent. net extra; 2 in. and larger, over 22 ft., 10 per cent. net extra.

Note—Boiler tubes are practically out of the market. Can be obtained from the mill only on long promises of delivery. Customer will probably have to shop around until he finds a stock.